VOL. XLV, NUMBER 1 WHOLE NUMBER 388

THE JOURNAL
OF
THE ROYAL ASTRONOMICAL SOCIETY OF CANADA

DEVOTED TO THE ADVANCEMENT OF ASTRONOMY AND ALLIED SCIENCES

EDITOR, C. A. CHANT ASSISTANT EDITOR,_____

David Dunlap Observatory
Richmond Hill P.O., Ont.

ASSOCIATE EDITORS:

C. S. BEALS
Dominion Astronomer
Ottawa

J. A. PEARCE
Dominion Astrophysicist
Victoria, B.C.

A. THOMSON
Controller of the Meteorological Service of Canada, Toronto

PUBLISHED BI-MONTHLY
(*Six numbers per year*)

January-February, 1951

PRINTED FOR THE SOCIETY
TORONTO: 3 WILLCOCKS ST.

THE JOURNAL
OF
THE ROYAL ASTRONOMICAL SOCIETY OF CANADA

VOL. XLV, No. 1 JANUARY-FEBRUARY, 1951 WHOLE No. 388

Articles **Page**

Frank Scott Hogg, 1904-1951 (with Plate I) ..... *C. A. Chant* (Editor) 1
The Frank S. Hogg Memorial Scholarship Fund ..... *J. F. H.* 4
The Trials of Galileo ..... *Arthur R. Clute* 5
Some Characteristics of 10.7-Centimetre Solar Noise, I *A. E. Covington* 15
The Atmosphere of the Late-type Stars (with Plate II) *Andrew McKellar* 23

Notes and Queries

Death of Mr. H. W. Barker 36

Out of Old Books

Le Gentil and the Transits of Venus, 1761 and 1769 (to be continued) *Helen Sawyer Hogg* 37

Review of Publications

Latin Treatises on Comets between 1238 and 1368 A.D., by Lynn Thorndyke (*C. A. C.*); *Der Sternenhimmel, 1951*, published by H. R. Sauerländer and Co.; *The New Zealand Astronomical Handbook, 1951*, published by the Royal Astronomical Society of New Zealand (*William Hossack*) 45

Meetings of the Society

At Toronto—At London 47

Address of Editors: David Dunlap Observatory, Richmond Hill, Ont.

Business correspondence and remittances should be addressed to J. H. Horning, Treasurer of the Society, 3 Willcocks St. Toronto.

$3.00 per annum, Single number, 50 cents.

Subscription to the JOURNAL is included in membership fee.

We offer for sale Lenses, Prisms, Telescopes, Binoculars, Microscopes, Magnifiers, etc.

We grind and polish our own lenses.

We also repair optical instruments of all types.

As an introductory offer we have a 3″ diameter 40″ focal length achromatic objective, priced at only $19.50 plus tax.

PRECISION OPTICS

32 YONGE BLVD. TORONTO, ONTARIO

MAyfair 4930 — LYndhurst 9046

PRINTED IN CANADA

PLATE I

FRANK S. HOGG (1904-1951)

THE JOURNAL

OF

THE ROYAL ASTRONOMICAL SOCIETY OF CANADA

VOL. XLV, No. 1 JANUARY-FEBRUARY, 1951 WHOLE No. 388

FRANK SCOTT HOGG, 1904-1951

By C. A. CHANT (Editor)

(With Plate I)

IT is with great regret that I record the death of Dr. Hogg. He was Professor of Astronomy and Director of the David Dunlap Observatory, in the University of Toronto; and from 1937 he was Assistant Editor of this JOURNAL and of the OBSERVER'S HANDBOOK.

Frank Scott Hogg was born at Preston in the county of Waterloo, Ontario, on July 26, 1904, the son of James Scott Hogg, a well-known physician, and Ida Mary Barber, a B.A. of the University of Toronto. He attended the local high school and also the Collegiate Institute at near-by Galt.

In the University of Toronto he pursued the course in Mathematics and Physics, and graduated in the Division of Astronomy in 1926. He obtained first class honours and was awarded the gold medal offered by the Royal Astronomical Society of Canada for first place in that branch. He then went to Harvard University where he obtained the A.M. degree in 1928 and Ph.D. in 1929. His was the first Ph.D. degree granted in Astronomy by Harvard. He specialized in stellar spectrophotometry.

Dr. Hogg was awarded the Parker Travelling Fellowship and spent a year at Cambridge University in England and in visiting observatories in Europe and on the west coast. His first position in America was Research Associate at Amherst College, Mass., 1930-31.

After this, Dr. Hogg was on the staff of the Dominion Astrophysical Observatory at Victoria, B.C., and when the David

Dunlap Observatory of the University of Toronto was nearing completion he was appointed Lecturer in the Department of Astronomy in the University; that was his title in 1934-36. Then he was Assistant Professor, 1936-42, and Associate Professor, 1942-46.

In 1946 Dr. R. K. Young retired and Dr. Hogg succeeded him as Professor of Astronomy and Director of the Observatory, which position he held for just five years.

He was only forty-six. I had followed his course from the time he entered the University; and, along with his many admiring friends, hoped and expected that he would be able to give at least a score more years to the important positions he held.

This JOURNAL was started in 1907, and as the years passed I had been looking for some one who might be Assistant Editor and relieve me of some of the responsibility and labour. In 1937 I asked Dr. Hogg if he would undertake it. He cheerfully agreed, and I found he had the taste and the special ability for such work.

The OBSERVER'S HANDBOOK also began publication in 1907, but it was called the *Canadian Astronomical Handbook* for two years. Then, in 1909 and 1910, it was dropped and the phenomena were printed in the JOURNAL; but that was not satisfactory and the annual publication was started again, and it has continued ever since. In its preparation, which is now done largely at the David Dunlap Observatory, Dr. Hogg had for some years relieved me from responsibility, and it was chiefly his wise management which led to a much larger circulation and sphere of usefulness. In this matter his leadership will be sincerely missed.

At the Observatory Dr. Hogg's chief work was the determination of the radial velocities of the stars. The 74-inch telescope is especially efficient for this purpose, and all the members of the staff take part in this big programme. But numerous other researches are always under way and in them he was continually advising and assisting. His staff were very loyal to him. He aroused the interest of young men who often were attracted to the Observatory to engage in some research.

Dr. Hogg was President of the Royal Astronomical Society of Canada in 1941 and 1942. He was a member of the American Astronomical Society and during the week of his death had been

nominated as Councillor. He was chairman of the National Committee for Canada for the International Astronomical Union; and he was a member of the committee on navigation of the National Research Council of Canada. He was also interested in astronavigation and devised and constructed a new type of bubble sextant, the two-star sextant.

Further, our friend was a useful citizen in his community. He had just completed a term of five years on the High School Board of the Richmond Hill Area, the last two years being chairman. He was an active member of the village's only "service" Club; and had been its president; and he was the first president of the Men's Club of the Richmond Hill United Church.

In 1930 Dr. Hogg was married to Helen B. Sawyer, a Ph.D. of Radcliffe, well-known for her researches into Globular Star Clusters. They met when they were graduate students. Mrs. Hogg has been for some years Research Associate in the department of astronomy at the University, spending a part of her time in giving instruction in Toronto, and also carrying on research at Richmond Hill. A part of her husband's labours was to assist her in taking photographs of star clusters at the prime focus of the 74-inch telescope in order to secure material for continuing this research. Mrs. Hogg has now been given a permanent appointment on the staff as Assistant Professor.

There are three children, a daughter at the University and two sons in high school.

Following a few days' illness with bronchitis, death came from heart failure at noon of the first day of the new year, 1951. A funeral service was held in the United Church at which the attendance was large and representative. The Dominion Astronomer (Dr. Beals) from Ottawa, Mr. J. W. Duffie of Montreal Centre of the R.A.S.C., and others from a distance, also high officers of the University, and many others were present to show their great respect for Dr. Hogg and regret for his untimely passing. During the service R. L. Baglow, of the staff of the Observatory, sang Addison's "The spacious firmament on high". Burial was at the village cemetery.

David Dunlap Observatory,
Richmond Hill, Ont.

FRANK S. HOGG MEMORIAL SCHOLARSHIP FUND

It is proposed to establish at the University of Toronto a Scholarship in Astronomy as a memorial to Dr. Frank S. Hogg, Head of the Department of Astronomy and Director of the David Dunlap Observatory, who died early this year. For this purpose a committee has been formed to raise a scholarship fund.

One of Dr. Hogg's chief interests was his students; many young Canadian astronomers owe a great deal to his encouragement and inspiration. Dr. Hogg deplored the fact that no scholarship existed in Canada expressly to aid a student towards beginning an astronomical career. Such a scholarship, therefore, would seem to be a fitting memorial to one to whom Canadian astronomy owes so much.

The University of Toronto is the only Canadian University which offers post graduate degrees in astronomy. Graduates of other Canadian Universities and of American Universities have come here to pursue graduate work in astronomy. It is hoped that the scholarship fund may reach such a total as to serve each year to help substantially one such student.

President Sidney Smith of the University of Toronto has endorsed this plan and has stated that all individual gifts will be acknowledged by receipts valid for exemption for income tax under the provisions relating to charitable donations.

The National Council of the Royal Astronomical Society of Canada has offered support for the plan and has appointed three members to the general committee which is as follows:

Dean S. Beatty, Department of Mathematics, University of Toronto.
Prof. J. F. Heard, Acting Director of the David Dunlap Observatory.
Mr. J. H. Horning, Treasurer, R.A.S.C., 3 Willcocks St., Toronto.
Prof. H. J. C. Ireton, Department of Physics, University of Toronto.
Mr. E. J. A. Kennedy, Secretary, R.A.S.C., 3 Willcocks St., Toronto.
Miss Ruth Northcott, Department of Astronomy, University of Toronto.
Mr. Andrew Thomson, Controller of the Meteorological Service of Canada, Toronto.
Mr. J. O. Wilhelm, Director of the Research Council of Ontario, Toronto.
Prof. R. E. Williamson, Department of Astronomy, University of Toronto.

Any who wish to honour Dr. Hogg's memory by making a gift to this scholarship fund may do so to any of the aforementioned committee members. Cheques should be made payable to the University of Toronto and may be marked *Frank S. Hogg Scholarship Fund*. Interim acknowledgment will be made immediately and official acknowledgment by the University later.

J. F. H.

THE TRIALS OF GALILEO*

by Arthur R. Clute

THE trials of Galileo—if indeed they can be called trials—took place in the years 1616 and 1632-1633. To a proper understanding of the real matter at issue involved in these so-called trials, some knowledge of the mental outlook and of the intellectual level of Europe in that era is essential. It has been said that "the age of reason in Europe was ushered in by an astronomical controversy", raised and carried on by the ecclesiastical authorities dominant at that period. The controversy was whether the earth is the greatest body in the universe, around which, as an immovable centre, the sun, planets and stars revolve, ministering, and intended by an all-wise Creator to minister, by their light and other qualities to the pleasures and necessities of man, or whether it is an insignificant orb—a mere point—submissively revolving, among compeers and superiors around a central sun. The former of these views was authoritatively and dogmatically asserted by the Church; the latter was timidly—indeed at first (because of the known or suspected attitude of the Church) even fearfully,—suggested by a few thoughtful men, but in the end it gathered strength and ultimately prevailed. Behind the physical question—a purely scientific problem—lay something, which in the view of the theologians was of the utmost importance, namely, the position and importance of man in the universe.

About the year 1507 Copernicus (1473-1543) had composed his renowned "De Revolutionibus Orbium Coelestium," in which he had enunciated the heliocentric theory. Though written in 1507, it was not until the year of Copernicus' death, in 1543, that his great work was published; the delay being due to the indisposition of Copernicus to encounter the bitter and cruel persecution to which, with good reason, he apprehended the publication of his theory, so radically at variance with the dominant theologies, both Roman Catholic and Protestant, would certainly subject him.

"De Revolutionibus" utterly revolutionized science; but, against the opposition it had to encounter, the heliocentric theory made its

*Editorial Note.—Adapted from an address to the Toronto Centre of the R.A.S.C., of which the author was president, 1949 and 1950. Mr. Clute was for some years a lecturer in the Osgoode Hall Law School, Toronto.

way but slowly at first. Luther speaks of "this fool Copernicus, who wants to overturn the whole science of astronomy"; Melanchthon urged the suppression of such mischievous doctrine by the secular power; and so learned an early modern scientist as Francis Bacon could not comprehend it and positively rejected it. It is therefore not to be accounted extraordinary that the Holy Office of the Roman Catholic Church should have denounced as heretical a doctrine completely opposed to the Ptolemaic system, which had prevailed unquestioned since 150 A.D.; and that it should have caused to be burnt at the stake in Rome, in February 1600, the Italian Dominican monk, Giordano Bruno, for promulgating a theory held to be monstrous and obviously untrue and perverse because irreconcilable with the tenets of the Church.

Yet at this time were living Tycho Brahe (1546-1601), Kepler (1571-1630), and Galileo (1564-1642), of whom it has been said that in the history of astronomy there has seldom been a period when three such distinguished men were active in the study of the sky. Alone of the three, Tycho did not accept the Copernican system, partly, it is said, on account of the absence of parallactic shifts in the stars, and partly because of scriptural prejudices; though he favoured a system of his own in which the planets moved round the sun; but the sun with its planets and the moon revolved round the earth. Kepler and Galileo, however, were converts to, and fully convinced of, the truth of the Copernican theory; and it was because of Galileo's adherence thereto that he incurred the enmity of the Inquisition, which resulted in the so-called trials in 1616 and 1632-1633 some incidents and details of which are about to be related.

Galileo Galilei (born at Pisa in Tuscany in 1564) was appointed in 1589 professor of mathematics at the University of Pisa, where he carried out a series of investigations, which revealed such a revolutionary attitude to the doctrine of Aristotle, as to make his relations with the University authorities far from harmonious; and ultimately in 1591 led to his resignation. For several years thereafter he occupied the chair of mathematics at Padua. But it appears he longed to return to his beloved Tuscany, and by 1610 his fame had become so great that the Grand Duke of Tuscany wished to have him resident in Florence, in the belief that he would shed lustre on the Duke's dominions; in consequence whereof Galileo in 1610 received the appointment as a professor at Pisa, and also as "First Philosopher and Mathematician" to the Grand Duke.

In 1609 Galileo heard that a Dutch spectacle-maker, Lippershey or Lippersheim, had made an instrument, consisting of two lenses which magnified distant objects. With this slender information, little more than a hint, and with no knowledge of the particulars of the instrument's construction, Galileo invented a form of the instrument for himself; one that could magnify thirty times. On turning it to the sky in January 1610 he was rewarded by a remarkable series of discoveries by which his name quickly became celebrated throughout Europe. These included the mountains, craters and plains on the moon; four satellites circulating around Jupiter; Venus showing phases like the moon; disks of appreciable size to the planets, which he saw were not points of light like the fixed stars; spots on the sun, which appeared to rotate round it in 27 days; 36 stars in the Pleiades, where ordinary eyesight shows only 6 or 7; and the Milky Way as composed of myriads of stars. The Ptolemaic theory was disproved by the phases of Venus; and the Copernican system brilliantly illustrated by these phases, the satellites of Jupiter and the sun's rotation. Some of Galileo's discoveries were denied existence by opponents; and the chief consequence of his observations and deductions from them, which should have been the complete overthrow of the Ptolemaic system, was a stream of opposition from the Schoolmen and from the Roman Catholic Church clergy, which was so strong and menacing that Galileo had to publish his expositions as hypotheses rather than as an actual system. What is meant by that is this. At the beginning of the 17th century, to speak of Copernicus' heliocentric theory as an hypothesis was not deemed by the authorities as heretical and criminal; but to teach it openly was perilous. It had become more and more difficult to maintain this position. The facts revealed by Galileo's telescope were palpably inconsistent with the old Ptolemaic system; he had verified the Copernican doctrine by his striking discoveries. He did what so many did—he equivocated; if he did not equivocate, he spoke with reservations more or less guarded. It was a time of terror to all who thought freely, and therefore a time of subterfuge. The choice might be between death, silence, recantation or equivocation. The last in some of its many forms was so much the easiest. Tyranny was met by cunning, intolerance by deception. Sometimes the innovators found refuge with a Prince (as in Luther's case) who sheltered them. More often their only refuge was in some system of subtle reservations, or in a double

set of incompatible beliefs, or in irony, perceptible only to the initiated!

Not by constitution a fighter (as Bruno in his conflict with the Inquisition, and as Servetus in his losing contest with Calvin had shown themselves to be), too much interested in his investigations to seek to end them by martyrdom, Galileo avoided battle with the Church. He knew the powers of the Inquisition, but unfortunately he had made a slip. He had written a letter in 1613 which revealed his real belief in the Copernican system. Becoming conscious that vigorous opposition to his views was increasing, he visited Rome in 1611, where he was given a friendly reception by Pope Paul V and by Cardinal Bellarmine, then in a position of transcendent power, and Bellarmine raised no objections. But, quite unknown to Galileo, his enemies were at work, and about that time preliminary steps against him were taken by the Holy Office. In February 1615 a certain Dominican of Florence transmitted to the authorities in Rome a copy of a letter of December 21, 1613, written by Galileo to a devoted friend and pupil, wherein it was asserted: that the Bible and Nature are both compatible with the Copernican system, that the decrees of Scripture cannot err, but its interpreters and expositors may, especially when they adhere to the literal truth, which would lead to contradictions; that professors of theology should not assume authority on subjects which they have not studied; that it would be the part of wisdom not to allow anyone to apply passages of Scripture in such a way as to force them to support as true conclusions concerning Nature, the contrary of which may afterwards be revealed by the evidence of our senses or by necessary demonstration; and that it is not in the power of any human being to make statements true or false, or other than they *de facto* are.

At this time it was deemed necessary by the Holy Office to define the position of the Papacy towards the Copernican theory, which hitherto had been regarded with suspicion, but had never formally been condemned; and so, on February 23, 1615, a decree was issued by the Inquisition declaring heretical the following two propositions, thus expressed: first that, "the sun is the centre of the world and immovable from its place": and secondly that "the earth is not the centre of the world and is not immovable, but moves, and also with a diurnal motion." The first proposition they said was "foolish and absurd in Philosophy, and formally heretical". The

second was "equally censurable in a philosophical point of view, and as theological truth, but less erroneous in faith."

Rumours having reached Galileo in Florence of what was going on he went to Rome in February 1616, not in consequence of a citation, but as he himself said, "of my own accord, without being summoned". When he arrived he was informed of the censure which had been passed upon the Copernican doctrine, and was admonished by Cardinal Bellarmine not to treat in any way of the immobility of the sun or the motion of the earth, under penalty. The official note of the interview states that Galileo was commanded and enjoined

> to relinquish altogether the said opinion that the sun is the centre of the world and immovable and that the earth moves; nor henceforth to hold, teach or defend it in any way whatsoever, verbally or in writing; otherwise proceedings would be taken against him in the Holy Office.

On February 26, 1616, Cardinal Bellarmine reports Galileo's promise to obey:

> The tenor of which is that he would altogether abandon the said opinion, nor moreover would he in any way hold, teach or defend it; otherwise let there be process against him in the Holy Office.

Of this meeting Sir John Macdonell (in his well known and highly acclaimed "Historical Trials") makes this observation:

> It was a dramatic meeting, significant and memorable; one can think of few in history more so; the meeting of the old and the new, and at a crisis of both. No better representatives could have been found of both—Galileo, the bold investigator, pursuing scientific methods to their last consequences; the forerunner of modern science and its methods; Bellarmine, a great figure, how great it is not easy for us now to conceive; scholar, jurist, controversalist; a great arresting force; the most formidable fighter in the war then waging in Europe between the secular and ecclesiastical powers; a strange compound of gentleness and remorselessness, of severity to himself as well as to others; the author of the maxim *Mors hereticorum pax ecclesiae*, and who taught that everything was permitted to the subjects of excommunicated princes.

Before Galileo left Rome he, however, got from Bellarmine the remarkable certificate (May 26, 1616) in which the Cardinal denying the truth of calumnious reports says that:

> Signor Galileo has not abjured, either in our hand nor in the hand of any other person, here in Rome or anywhere else, so far as we know, any opinion or doctrine held by him, neither has any salutary penance been imposed upon him; but only the declaration made by the Holy Father and published by the Sacred

Congregation of the Index has been intimated to him, wherein it is set forth that the doctrine attributed to Copernicus that the earth moves round the sun, and that the sun is stationary in the centre of the world and does not move from east to west is contrary to the Holy Scriptures, and therefore cannot be defended or held.

The "first trial" was concluded on March 5, 1616, with the Decree of the Holy Congregation putting in the Index certain books, and condemning the false doctrine of Copernicus—as "an opinion *in perniciem Catholicae veritatis*" (to the destruction of Catholic truth). While it is usual to speak of "Galileo's first trial" the proceedings scarcely amount to that. There was a denunciation; but Galileo was not formally cited. He was not examined. He was not condemned to any punishment. He was merely admonished; and had proceedings ended there, little would have been heard of the first trial.

We come now to the "second trial" (1632-1633), which it has been said might perhaps not have taken place had Cardinal Bellarmine been still alive. Some sixteen years had passed; Galileo had continued his investigations; the proofs of the Copernican system had accumulated; he was in high esteem, though he had enemies whose power he underrated; he published no works openly defending the Copernican doctrine, though in letters to his friends (of whom Kepler is the most famous) he maintained or assumed it. Perhaps he was not very clear as to the exact scope of the injunction laid upon him or as to the nature of his promise. At all events he gave to his enemies an opening which they were quick to use. In 1632 he published his "Dialogue on the Two Principal Systems of the World, the Ptolemaic and the Copernican", a work in which two of the interlocutors defended by scientific reasoning the double movement of the earth, while the third interlocutor, named, perhaps with some significance, "Simplicius", supports with feeble reasoning the opinions of the Aristotelian school. In his preface to the "Dialogue" he states that he is proceeding with pure mathematical hypothesis, seeking by every method known to art to represent its superiority, not of course in an absolute sense, to the theory of the immobility of the earth, etc. He adds with irony:

I hope these considerations will prove to the world that, if other nations have been greater navigators, we have not been behindhand in speculation; and that if we fall back on the assertion that the earth is stationary, taking the opposite view merely by way of mathematical caprice, that does not arise from a

disregard of the many others who have given their attention to the subject, but, if for no other cause, by reason of the powerful support which is lent to it by piety, religion, and a consciousness of the weakness of the human mind.

For the printing of the "Dialogue" at Florence Galileo had experienced difficulty in getting a license. But the *imprimatur* had at last been granted; and the work met with great approval, when there suddenly burst upon its author a storm, much more violent than that from which he had escaped sixteen years before. First the sale of the book was stopped by order. Then a commission of theologians and men of science was appointed to examine it. In one month the commission made a report highly unfavourable to Galileo.

It found: (1) that without orders and without making any communication about it he put the *imprimatur* of Rome upon the title page; (2) that he had printed the preface in different type, and rendered it useless by its separation from the rest of the work; further that he had put the saving clause at the end in the mouth of a simpleton, and in a place where it is hard to find; that it is but cooly received by the other interlocutor, so that it is only cursorily touched upon and not fully discussed; (3) that he had very often in the work deviated from the hypothesis, either by absolutely asserting that the earth moves and that the sun is stationary, or by representing the arguments upon which these views rest as convincing and necessarily true, only making the contrary appear impossible; (4) that he had treated the subject as undecided and as if he were waiting for, though he did not expect, any explanation.

The report further found that he had broken the injunction laid upon him in 1616. The fact was he had fooled the Holy Congregation and subjected to ridicule the Papal decree. From that point things moved fast.

Under date September 23, 1632, there was an order from the Pope for Galileo to appear before the Commissary General; followed by further peremptory orders on December 9 and 30, 1632, the latter order stating that the Inquisition is no longer to tolerate "subterfuges" put forward for non-appearance on the grounds of great age, feeble health, blindness; Galileo is to be sent to Rome, "imprisoned and put in irons". The Pope was angry and inflexible, insisting that though Galileo might, because of age and feebleness, be permitted to travel only slowly and in a litter, yet he must be

tried in Rome in person. Galileo, overwhelmed with grief and in despair, writes to a friend:

> This vexes me so much that it makes me curse the time devoted to these studies in which I strove and hoped to deviate somewhat from the beaten track generally pursued by learned men. I not only repent having given the world a portion of my writings, but feel inclined to suppress those still in hand and to give them to the flames and thus satisfy the longing desire of my enemies, to whom my ideas are so inconvenient.

So to Rome he had to go, travelling by litter, and reaching it in February 1633; and on April 12 he appeared before the Inquisition. He was questioned mostly as to his interview with Bellarmine in 1616. According to him, Bellarmine allowed him to treat the Copernican doctrine *ex suppositione:* It might be held hypothetically and written about in this sense. He said that he did not understand the agreement; that he had never bound himself not to teach the Copernican doctrine; pressed in cross-examination, he admits that he may have been told that he was commanded not to hold or defend the doctrine. He says: "It may be that the words 'and not to teach' were also there. I do not remember it, neither the definitive words, 'in any way whatsoever' (*quovis modo*)". So far he was not treated harshly; large comfortable apartments were put at his disposal for himself and his servants; he was a prisoner only in name.

On April 30, 1633, was the second examination, and with it came an astounding change. At the first hearing he had denied that he had maintained the Copernican doctrine or broken any command or promises. He now admitted his error; he owned that there is some taint of disobedience in his writings.

> My error, then, has been—and I confess it—one of vainglorious ambition and of pure ignorance and inadvertence.

He went farther in his abject recantation.

> In confirmation of my assertion that I have not held and do not hold as true the opinion which has been condemned,—of the motion of the earth and the stability of the sun—if there shall be granted to me, as I desire, means and time to make a clearer demonstration thereof, I am ready to do so.

Which was worse, asks Sir John Macdonell, the tribunal which burnt Bruno, or that which extorted such a humiliating confession from Galileo? But the cup of humiliation was to be drunk to the dregs. On May 10, 1633, was held another hearing. Galileo urges

that in the course of fourteen to sixteen years he had forgotten the injunction not to hold or teach in any way the obnoxious opinions. He urged too, in mitigation, his advanced age and pitiable bodily indisposition. Still the Congregation was not satisfied. It was part of the jurisprudence which it administered not to be content with merely verbal confessions; it would pry into the most secret recesses of the conscience in order to detect the true belief. Therefore on June 16, 1633, the Holy Congregation decreed:

> The same Galileo to be questioned as to his intention, and under threat of torture, and, if he persists, he is to be called upon to recant in full meeting of the Holy Office, condemned to prison at the will of the Holy Congregation, and ordered also that no more by writing or speech shall he discuss in any way whatsoever the movement of the earth nor the fixedness of the sun, nor the contrary opinion, on pain of being treated as having relapsed.

On June 21, 1633, there was further examination and again an abject confession:

> I do not hold and have not held this opinion of Copernicus since the command was intimated to me that I must abandon it; for the rest I am here in your hands, do with me what you please.

The report here says:

> Being told that he should tell the truth, otherwise he would be brought to the torture:

the broken old man could but say,

> I am here to obey, and I have not held this opinion since the decision was pronounced, as I have stated.

We come to the final scene on June 22, 1633, his sentence and recantation: *sentence*—that the publication of the "Dialogue" be prohibited, and that Galileo be condemned to the formal prison of the Holy Office during pleasure: *recantation*—it was abject and unqualified. Having admitted that he had broken the injunction of the Holy Office as to holding and teaching the Copernican doctrines and that he is justly suspected, he proceeds:

> With sincere heart and unfeigned faith I abjure, curse and detest the aforesaid errors and heresies, and generally every other error and sect whatsoever contrary to the said Holy Church; and I swear that in future I will never again say or assert, verbally or in writing, anything that might furnish occasion for a similar suspicion regarding me.

There was no physical torture, there was no dungeon, but no humiliation was spared him. There is a story that, as he rose from

his knees, after his recantation, he murmured to a friend: "But it does move". Macdonell, however, emphatically says: "He never said anything of the kind. It was the last thing—in that dreadful place where he had no friend—he would have thought of saying. It was said *for him* more than 150 years after his death".

What a spectacle! This venerable man, the most illustrious of his age, forced by the threat of death to deny facts which his judges as well as himself knew to be true! "The sentence", says Sir John Macdonell, "was, if not the greatest, at least one of the most serious mistakes which the Roman Curia has made, though that body expiated it—perhaps not yet in full—on the day when it had to expunge the condemned 'Dialogue' from the Index, and inscribe in the very volumes of the *Decreta* permission to teach, uphold, and defend that doctrine, which it had already declared to be absurd, philosophically false and formally heretical".

SOME CHARACTERISTICS OF 10.7-CENTIMETRE SOLAR NOISE, I

By A. E. Covington

FOR the past three years observations of the intensity of radio radiation from the sun (solar noise) have been conducted on a daily basis with a radio telescope responding to a wave-length of 10.7 centimetres at the National Research Council in Ottawa. The intensity of the radio emission varies from day to day, and is closely associated with the appearance and disappearance of sun-spots, as shown either by the number of sun-spots or by the total sun-spot area. On any given day, there may occur sudden violent increases of the radio emission; these bursts of radio noise may last for a number of minutes. The bursts may occur simultaneously with solar flares, or, when no direct evidence is available, they may be associated with the corresponding radio fade-out. These results were apparent immediately in 1947, and were reported in the Proceedings of the Institute of Radio Engineers.[1] The continued observations have confirmed these results and have provided a group of bursts which can now be analyzed. The Ottawa observations will be reported in two separate parts; the present paper deals with the daily levels of solar emission, while the second part (which will appear in a subsequent issue of this JOURNAL) will discuss the observations of bursts of solar noise.

Apparatus.—During he three year period, 1947-1949, the original radio telescope consisting of a dipole and reflector placed at the focus of a four-foot parabolic reflector has been used without any alterations, while the superheterodyne receiver has been used with occasional replacement of components. It is believed that the interchange of parts can introduce errors in the calibration of about 5 per cent. In order to reveal the fine structure of the noise bursts it is necessary to record with short time-constant circuits and with the paper moving at a high speed. Consequently, additions have been made to the output circuit in order to provide for additional recording meters. Since September 1948, records of solar noise bursts have been taken with different chart speeds and time constants, as follows:

[1] A. E. Covington, *Proc. Inst. Radio Eng.*, vol. 36, p. 454, 1948.

	Chart Speed	*Time Constant*
Low Speed:	1½ inches per hour	7 seconds (original)
Medium Speed:	12 inches per hour	½ second
High Speed:	1½, or ¾ inch per minute	½ second

The 10.7–centimetre solar emission collected from the antenna is just a small fraction of the energy produced by the random thermal agitation of the electrons in the resistors and tubes of the first few stages of the receiver, and suitable means[2] is provided to cancel the average value of this unwanted receiver noise so that only the antenna energy is recorded on the output meter. A convenient measure for the expression of the intensity of solar radiation is the equivalent temperature of the antenna radiation resistance. This can be found by calibrating the receiver in terms of the temperature of a resistance which replaces the antenna and is heated to various known values. Since the receiver can detect this radio heat emission readily, it is sometimes called a radiometer.

Units.—When the radio telescope, with its acceptance cone of six degrees, is pointed towards the sun, radiation is received from the background of empty sky at a temperature of nearly absolute zero, as well as from the hot sun. As a result, the radiation resistance of the antenna reaches an average value of temperature between sun and sky which is given by the equation:

$$T_{ant} = T_{\odot} G_m \phi / 4\pi \qquad (1)$$

where, T_{ant} = temperature of the antenna radiation resistance
$T_{\odot}$ = equivalent temperature of the sun
G_m = maximum antenna gain = 700
ϕ = solid angle of the sun = 6.8×10^{-5} rad².

This equation is used to obtain the equivalent 10.7–centimetre temperature of the spotless sun under the assumption that the visible disk emits the radio waves uniformly.

The solar radiation is also expressed in terms of a unit with the dimensions of watts/square metre/unit band-width (in cycles per second). The noise power in terms of watts/cycle per second detected by the radiometer is given by Nyquist's Theorem and is equal to $k\ T_{ant}$, where k is Boltzmann's constant, and T_{ant} is the equivalent temperature of the antenna radiation resistance. The

[2]R. H. Dicke, *Rev. Sc. Inst.*, vol. 17, p. 268, 1946.

area (0.64 square metres) over which this plane polarized energy has been collected is that of the four-foot parabolic reflector, using an efficiency factor of 55 per cent. The intensity in watts/square metre/cycle per second for two polarizations is obtained by dividing $2\,k\,T_{ant}$ by the equivalent area.

Calibration.—A measurement of the daily intensity of the solar noise expressed in terms of the antenna temperature is obtained readily after the receiver has been calibrated. This is done by connecting successively two different sources of 10.7-centimetre radiation. First the antenna is pointed towards the empty sky which has an equivalent temperature of about 50° K., and second, the dipole is enclosed in a small box which is at earth temperature and appears as a black body to the radio waves. The antenna is next pointed towards the sun and the temperature difference between sun and sky is found by linear extrapolation from the calibrations made previously. A calibration recorded at $9^h\ 30^m$ E.S.T. on June 22, 1949 is shown in figure 1. The fine fluctuation in the trace is due to the residual receiver noise.

The temperature of the empty sky has been investigated with a second radiometer which has an antenna pointing permanently towards the zenith. The receiver output is likewise calibrated by removing the antenna and substituting two equivalent resistances, one maintained at 200° C. and the other at the earth's temperature. The first measurements of the sky temperature yielded a value of 50° K., while later results taken with improved equipment showed a value nearer absolute zero. In all the solar noise work the temperature of the empty sky has been used as one calibration point, with a constant value of 50° K. This value is used whether or not any measurement has been made. In view of a series of daily sky readings taken during 1949, the only error introduced would systematically change the whole level of solar noise, since the recorded daily fluctuations of the sky temperature show no correlation with any of the solar variations. These apparent daily fluctuations about a mean level are about $\pm$ 20°, and appear to be of instrumental origin. For example, the mean level changes by about this amount when the crystal mixers are tuned differently. In the future, when several small errors have been corrected, it is hoped that a more reliable calibration of the radiometers can be made.

The observed background radiation can have its origin in the galaxy or as an emission from the atmosphere of the earth. Attempts to observe the differences in galactic noise arriving from the direction of the long wave-length maximum located in Sagittarius and from the colder parts of the sky show that this difference is certainly below an antenna temperature difference of 10° K. The emission from the atmosphere of the earth directly overhead gives rise to an

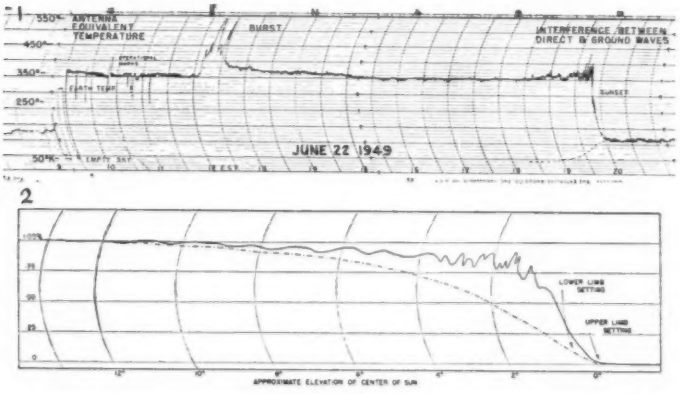


FIG 1.—Record of solar noise on 10.7 cm. showing a noise burst superimposed on a steady background

FIG. 2.—Variations of solar radio and infra-red emissions at sunset. *Solid line:* 10.7 cm.; *broken line:* infra-red.

equivalent antenna temperature at first measured as 50° K. A value of about 10° K. for the sky temperature has been derived from the temperature difference observed when the antenna was tipped from the zenith to that elevation which doubled the path thickness within the earth's atmosphere. The emission from the earth's atmosphere is also deduced from Kirchhoff's Law, and is proportional to the fractional absorption coefficient times the temperature of the absorbing medium.

Atmospheric Absorption.—The atmospheric absorption is directly apparent only when the sun sets and a great thickness of the atmosphere is traversed by the rays. Simultaneous records of the ten-centimetre and the infra-red solar radiations for about one hour

just before sunset on March 19, 1949, are shown in figure 2 (see also a similar period in figure 1). Until this time, corresponding to an elevation of 10°, the ten-centimetre solar intensity remained appreciably constant; then as the sun moved to lower elevations, the radiation was first reduced gradually, and then rapidly just as the sun set. At such low elevations when the horizon was in the antenna acceptance cone, the recorded readings should be corrected for a ten-centimetre thermal component emitted from the earth. In figure 1, the amount of this radiation is shown by a dashed line, and must be subtracted from the total radiation received in order to find the true solar emission. Such a correction has been applied in the plotting of figure 2. The fluctuations present on the ten-centimetre solar noise curves just before sunset resulted from the interference formed by the direct rays and the rays reflected from the earth. On March 19, 1949, the reflections were from snow-covered rolling hills. The fluctuations were sometimes of great complexity when spots were present, and were roughly reproducible on successive days. Undoubtedly effects from the varying state of the lower atmosphere and the physical details of the horizon were also present in the detailed analysis of the curve. Using a very simple model, the attentuation introduced by the atmosphere is found to be about 0.01 decibels per kilometre. The presence of clouds did not introduce any measurable attenuation of the solar emission. Heavy rains introduced variable local attenuation through the wetting of the surface of the plastic dipole housing.

These preliminary observations of negligible emission from the galaxy and very small attenuation in the earth's atmosphere showed that any possible effect on the solar noise observations will be of secondary importance.

Since the radio telescope, with its 6° cone of acceptance, can receive energy from the sky which appears adjacent to the sun, a radio emission due to a secondary process associated with the disturbed conditions of the upper atmosphere may be received during a radio fade-out. Any such radiation coming from the upper atmosphere could be detected by the second radiometer whose antenna was pointing towards the zenith. During the period under consideration simultaneous records of the sky noise were obtained for about 90 per cent. of the solar noise bursts, and only two cases showed noise coming from the upper atmosphere. These occurred

simultaneously with radio fade-outs on May 21, 1947, at $15^h\ 30^m$ G.M.T., and on August 4, 1948, at $17^h\ 12^m$ G.M.T. During the night similar bursts of noise have been detected occasionally during auroral displays and geomagnetic disturbances.[3]

Daily Level of Solar Noise.—During the course of a day the solar noise remains very constant and consequently the radiometer is calibrated once a day (around 10^h E.S.T.). From the large variations in intensity which occur from day to day, particularly

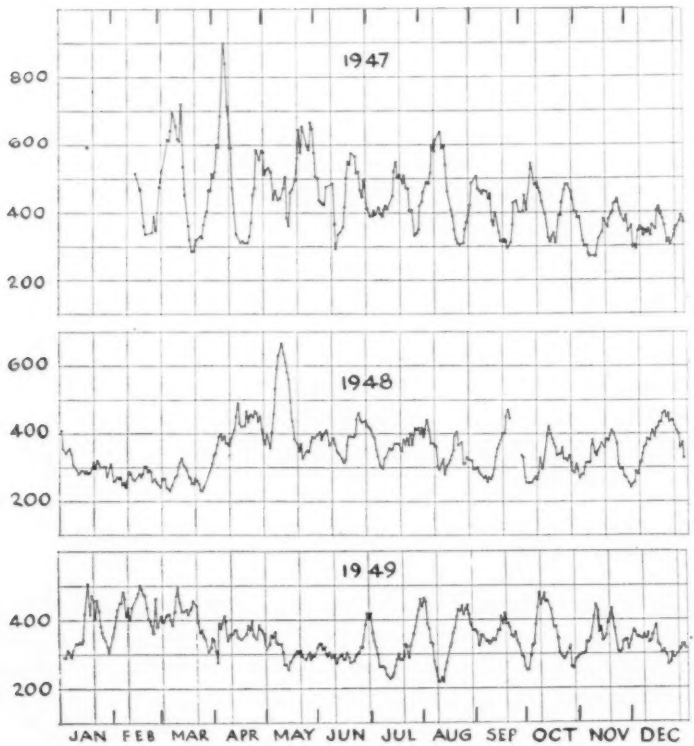


FIG. 3.—Daily levels of 10.7 cm. solar noise plotted for 1947, 1948, 1949.

[3]A. E. Covington, *Terr. Mag. and Atmos. Elect.*, vol. 52, p. 339, 1947.

when an active region is coming into or going out of view, one would expect a gradual change in intensity to occur during the course of a few hours. As yet no good experimental evidence has been obtained to show such a gradual change. On the other hand, sudden changes in the level of intensity have been observed to follow some bursts which have a post-storm level greater than the pre-storm level. Such a burst, with a post-storm increase is shown in figure 1.

The daily observations for three years—1947, 1948 and 1949—are shown plotted in figure 3, with the antenna temperature as ordinate. These curves reveal that the radiation fluctuates with a period of about twenty-seven days, and always appears to increase from a relatively constant level. The excess radiation is from the vicinity of sun-spots, while the background radiation is from the undisturbed regions of the solar atmosphere, predominantly from the chromospheric level, with a small contribution from the corona. The minimum solar noise level for 1947, as represented by the antenna temperature, remained at 300° K. This corresponds to an equivalent temperature of 8×10^4° K., as calculated from equation (1). Early in 1948, when the sun-spot area reached a low value of about 100-millionths of the visible disk, the noise level decreased to about 230° K. This quiet sun level, also apparent a few times in 1949, corresponds to a quiet sun value of 6×10^4° K., and is the lowest value on record.

Denisse[4] has attempted various correlations with other solar data and has obtained successively better fits by comparing the daily intensity with (*a*) American relative sun-spot numbers; (*b*) Summation A; and (*c*) Summation $A \cdot H_0/\sqrt{A}$, where A is the true spot area corrected for foreshortening, and H_o is the maximum magnetic field. The last index is composed of two factors: A, and $H_0/\sqrt{A}$. The latter factor is always close to unity and its presence introduces a small correction which makes a better fit. This was particularly pronounced for the year 1947, but for 1948 there is only a small improvement. The close correlations of the ten-centimetre noise variations with the sun-spot area (correlation coefficient > 0.8) permits the temperature of the ten-centimetre

[4]J. F. Denisse, *Comptes Rendus*, vol. 228, p. 1571, 1949; "Thèse de Physique," École Normale Supérieure, Paris, 1949.

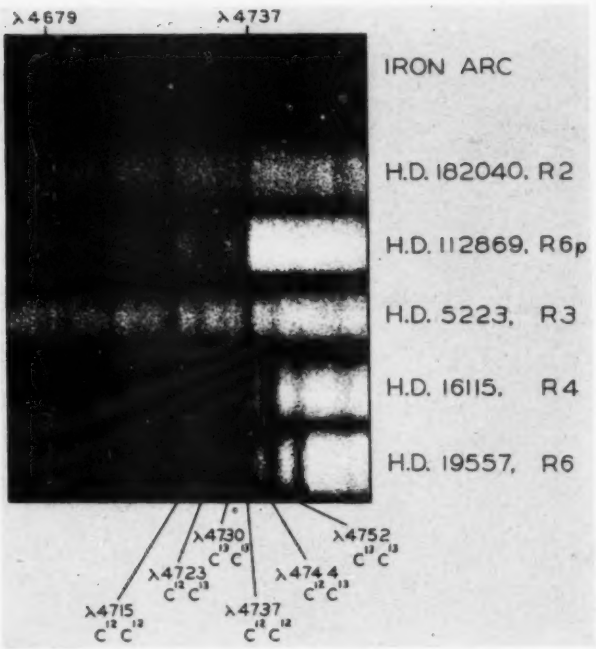
emitting surface which exists over the sun-spot to be estimated as 7.5×10^6° K. This evaluation is based on the assumption that the emitting surface is the same as the sun-spot area, and is in rough agreement with the minimum value of 1.5×10^6° K. calculated from the temperature drop which occurred when the moon covered a large group during a partial eclipse.[5]

(*To be concluded.*)

---

[5]A. E. Covington, *Nature*, vol. 159, p. 405, 1947.

PLATE II



SPECTRA OF R-TYPE STARS, SHOWING ISOTOPIC CARBON BANDS.

THE ATMOSPHERES OF THE LATE-TYPE STARS*

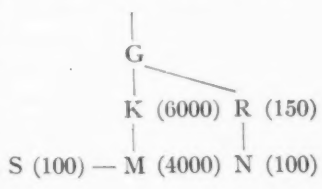
By Andrew McKellar

(With Plate II)

I PROPOSE to discuss the stars from those having somewhat lower temperature than the sun down to the coolest we observe. In round numbers, the surface temperature limits are from 5000° K. to 1500° K. It will be my purpose first, to give representative values of the various quantities used to describe the physical characteristics of the stellar atmospheres, indicating, where convenient, the general methods of obtaining the values, and, secondly, to discuss several interesting and important problems involving the atmospheres of the cool stars.

Spectral Classification

For the benefit of those who may not keep in mind details of stellar spectral classification, let me draw attention to the nomenclature of the classification as it applies to the late-type stars. The spectral types shown are divided into decimal-type sub-groups of 0 to 9. The sun is about type G2, and the principal sequence from the sun is the K–M extension. The other two off-shoots shown, R–N and S, are groups of relatively small numbers of stars, having interestingly different spectra. The relative numbers of stars of the different types are shown by the figures in parentheses. These numbers correspond roughly to those found from the Henry Draper Catalogue which extends in magnitude to a little beyond 8.5, so they contain such selection effects as are inherent in a group depending only on apparent brightness. However, the preponderance of the K–M stars shown is so great as to be unquestionably real.



The spectral features that distinguish the different groups are: (1) the M-type spectra exhibit absorption bands of TiO; (2) the R- and N-type spectra exhibit absorption bands of molecular

*A paper given as part of the symposium on "The Atmospheres of the Stars and Planets" at the Kingston meeting of the Royal Society of Canada, June 1950.

carbon, C_2, and of the carbon compounds CN and CH; (3) the S-type spectra exhibit absorption bands of ZrO. The spectral characteristics of the M and R–N stars are not known to coexist for any objects (except, faintly, for the sun), whereas those of M and S stars often do occur together. It is of interest to note that, in distinction to the objects of high temperature, the late-type stars are cool enough to permit the existence in their atmospheres of matter in the molecular state.

Late-Type Giants and Dwarfs

In addition to spectral classification, there is one further stellar characteristic requiring mention, namely intrinsic brightness. Fundamentally, the intrinsic brightness or, as usually expressed, the absolute magnitude of a star, is obtained from knowledge of its distance and its apparent brightness. The absolute magnitude is defined as the apparent magnitude the star would exhibit if it were at a distance of ten parsecs or 33 light-years. Other methods of obtaining absolute magnitude have been evolved, which have required calibration by the fundamental method. Important among these is the method of spectroscopic parallaxes, by which relative and absolute intensities of certain spectral features give fairly precise information on absolute magnitudes.

When absolute magnitude is plotted against spectral type, as first was done by Russell and by Hertzsprung, two decided trends are apparent, especially for the late-type stars, as shown in figure 1. It is immediately obvious that, say, for stars of type M2, there is a group with absolute magnitude about 10 and another with absolute magnitude slightly less than 0. Since, as will be recalled, the sun is of absolute magnitude + 4.8, and 5 magnitudes corresponds to a factor of 100 in luminosity, stars of the last group are about 100 times brighter intrinsically than our sun, whereas members of the first group are about 100 times less luminous than the sun. The two groups of stars of spectral type M2 thus differ in absolute brightness by a factor of 10,000. The bright group has been designated as the giant sequence and the fainter group, the main or dwarf sequence. In studying the late-type stars, we must therefore distinguish between giants and dwarfs. It is interesting to note that the masses of giant and dwarf stars do not differ nearly as radically as their luminosities, so that the late-type giants radiate

from 100 to 1000 times as much energy per gram of star material as do the dwarfs. This most interesting and significant point, which is beyond the scope of this discussion, must have a direct relation to the energy-generating mechanisms which are active deep in the star.

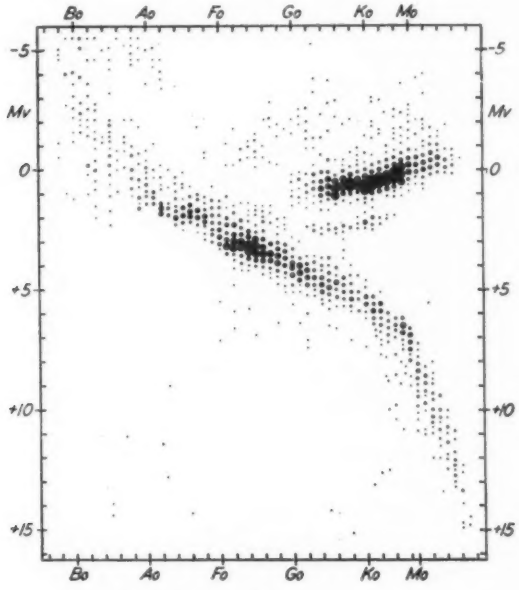


FIG. 1.—The Russell-Hertzsprung diagram.

PHYSICAL QUANTITIES DESCRIBING LATE-TYPE ATMOSPHERES

We shall now proceed to examine a table in which values of quantities describing the physical state of the atmospheres of late-type stars have been assembled. It is known that a stellar atmosphere is not a homogeneous layer of material, but that its effective extent varies for different wave-lengths of radiation and that it must exhibit certain temperature and pressure gradients. Indeed, we shall refer later to an interesting case, that of Zeta Aurigae, where information on the structure of a stellar atmosphere can be obtained more or less directly. However, in most of the theoretical

and observational studies made to date, it has been necessary to treat simplified models and to derive data in the nature of averages for the stellar atmosphere. Thus, in the table, the values given are to be taken as average values. Especially for the quantities derived from spectrographic observations, the table is not as complete for the dwarfs as for the giants. This deficiency arises from the much greater faintness of the dwarfs and the associated diffi-

	Giants	
	K, R types	M, N, S types
Temperature:		
Effective	4200 – 3500°K.	3400 – 1700°K.
Excitation, atoms	3500°K.	
Excitation, molecules	6000 – 3000°K.	2000 – 1500°K.
Surface Gravity, g (cm./sec.^{2})	∼6000	∼5
Pressure:		
Gas pressure (dynes/cm.^{2})	(∼100)	
Electron pressure (dynes/cm.^{2})	3×10^{-3}	$\sim 10^{-6} - 10^{-7}$
Linear Dimensions:		
Radial extent of atm. (km.)	$\sim 3 \times 10^7$	$(\sim 10^6 - 10^7)$
Stellar radius ⊙	∼200 ⊙	∼300 – 400 ⊙

	Dwarfs	
	K type	M type
Temperature:		
Effective	5000 – 3900°K.	3400°K.
Excitation, atoms	4200°K.	
Excitation, molecules		
Surface Gravity, g (cm./sec.^{2})	∼100,000	∼400,000
Pressure:		
Gas pressure (dynes/cm.^{2})	(∼10,000)	
Electron pressure (dynes/cm.^{2})	∼1	
Linear Dimensions:		
Radial extent of atm. (km.)	(∼400)	(∼100)
Stellar radius ⊙	∼0.5 ⊙	∼0.2 ⊙

culties of photographing them with instruments of moderately high dispersion. The figures of lower reliability or those derived mainly from theory without direct observational basis are shown in parentheses.

The quantities appearing in the table may be discussed in turn. As regards temperature, it is seen that the range is roughly from 5000° K. to 1500° K. Also, the temperatures of giants are somewhat lower than those of the dwarfs of corresponding spectral types. Two classes of temperature are given (there are several others in use for different purposes), the effective temperature and the excitation temperature. The effective temperature is defined as the quantity T_e in the equation,

$$L = 4\pi R^2 \sigma T_e^4 ,$$

where L and R are the stellar luminosity and radius, respectively, and σ the radiation constant. The definition is thus seen to depend directly on Stefan's law, and so on the total radiation from the star. The excitation temperature depends upon, and so gives a measurement of, the distribution of atoms and molecules among their different energy states. It is determined from the relative intensities of various spectral features. For atomic spectra, the intensities of lines of multiplets of different excitation potentials are assembled on a curve of growth, and the shifts necessary along the axis representing numbers of absorbing atoms are used to derive excitation temperatures. For molecular spectra, either the relative intensities of individual lines in a band or of bands within a system will give values of an excitation temperature.

The surface gravity, in combination with the temperature (and of course the chemical composition), determines the characteristics of the stellar spectrum. The surface gravity is seen to vary from values less than that on the surface of the earth for the coolest giants, to values enormously greater for the dwarfs. The surface gravity is derived from the values of stellar mass and radius. Stellar masses are found directly from the motions of binary stars in conjunction with the fundamental laws of motion. Reference will be made later to determinations of the radii of stars.

The pressures in the atmosphere, both total gas pressure and partial pressure of electrons, also vary greatly from giant stars to dwarfs. The greatly extended giant atmospheres might be ex-

pected to be at a much lower pressure and density than the atmospheres of the dwarfs. For purposes of comparison, the gas pressure and electron pressure in the solar atmosphere are about 60,000 and 20 dynes/cm.^{2}, respectively. It is worth noting too, the decreasing ratio of electron to total pressure with decreasing stellar temperature. For the hottest stars, with hydrogen the predominant constituent and ionization almost complete, the electron pressure makes up half the total pressure. For more and more advanced stellar types, where ionization is less and less, the electron pressure becomes proportionately smaller. It should be pointed out that the ratio of electron pressure to gas pressure depends not only upon the temperature and density but also upon the chemical composition assumed for the stellar atmosphere.

$$P/P_e = (N_o + N_e)/N_e$$

where N_o is the number of atoms and positive ions of all kinds and N_e the number of free electrons. The numbers depend upon the relative population of atoms of various ionization potentials, hence the dependence on composition.

The figures given in the table for the electron pressure have observational bases and the values of the total pressure are derived therefrom assuming a composition by numbers of H: He: Elements I.P ~ 8 volts: Elements I.P. ~ 6 volts of 100,000: 20,000: 40: 1.

The linear dimensions of the giants are much greater than of the dwarfs. Knowledge of the stellar diameters has been obtained in various ways which have given results in good accord. Included in the sources of data are: (1) Information on temperature and intrinsic luminosity, leading by the radiation laws to values of the surface area; (2) data from the radial-velocity and the light curves of eclipsing binary stars, giving radii in kilometres; and, (3) for the giants, direct measurement of the stellar radii by interferometric methods. In general, both from observation and from theoretical model-atmosphere computations, it has been found that the extent of the stellar atmosphere concerned with production of the absorption spectrum, both for giants and dwarfs, is of the order of one one-thousandth the stellar radius. This conclusion can be checked for the sun on direct photographs and for special cases, such as the giant eclipsing binaries Zeta Aurigae and VV Cephei, which will be discussed later.

Chemical Constitution

As well as has been determined from quantitative measurements on solar, stellar, nebular, etc., spectrograms, the general distribution of chemical elements is roughly the same throughout these aggregations of matter in greatly divergent physical states. The marked differences in the various spectra are accountable for on the basis of different physical factors such as temperature, pressure, etc. It is found that hydrogen is by far the most abundant element. Recent estimates from stellar spectra reveal that for each atom of any metallic element there are about six atoms from the group carbon, nitrogen, and oxygen, about 500 atoms of helium and about 5,000 atoms of hydrogen Among the cool stars, the main sequence G–K–M, appears to conform to the general picture. Not only from the study of atomic spectral lines but also from molecular bands, as first shown by Russell, the spectra of the K–M stars reflect a distribution of the elements resembling that of the solar atmosphere. However, when we consider the two relatively sparsely populated sequences paralleling the K–M stars, namely the R–N, and the S sequences, we seem faced with the necessity of accepting some variations in the chemical composition. The atmospheres of the M, N, and S giant stars show, so far as we know, about the same physical conditions. But, the spectra of the M stars show TiO bands; spectra of the N stars show bands of molecular carbon and carbon compounds, while spectra of the S stars show ZrO bands. It seems hard to escape the conclusion that carbon is relatively more abundant in the atmospheres of the R and N stars, and zirconium in the S stars. Suggestions along this line were made two or three decades ago, and are still accepted, largely because no other explanation of the observations is evident. Some support of the hypothesis, as applied to the R and N stars, was given by Russell's work on molecular association and dissociation in stellar atmospheres. In the solar and K- and M-type atmospheres, oxygen is about ten times as abundant as carbon. By reversing this abundance of carbon and oxygen, Russell found that the TiO bands would be replaced by those of carbon compounds, a change in agreement with the observed difference between the M-type and carbon stars. Thus, to summarize, it is accepted at present, at least as a working hypothesis, that the three spectral

divisions of the cooler stars arise from differences in chemical constitution of the atmospheres.

Interesting Problems

Zeta Aurigae and Similar Systems.—One of the most valuable sources available to astrophysicists for study of the atmospheres of late-type stars is the binary, Zeta Aurigae. This system consists of a giant star of spectral type K2 and a comparatively small hot star of late B type, revolving about their mutual centre of gravity in a period of 972 days. Most fortunately the plane of the orbits of Zeta Aurigae coincides closely with our line of sight from the solar system to the star, so the components of the binary eclipse one another. The eclipse of the small B-type star by the giant K-type is of special interest. Totality lasts about 38 days, definite partial eclipse by the deep atmosphere of the K star lasts about a day before and after totality, while spectroscopic evidence of the eclipse has been detected several weeks before and after totality.

It can immediately be seen that, from measurement of the stellar radial velocities and consequent knowledge of the orbits, linear dimensions of the stars and of the atmosphere of the late-type giant can be deduced.

More important, however, is the circumstance that during partial eclipse, the small hot star acts almost as a point source of continuous radiation travelling behind the atmosphere of the cooler giant star, giving us the chance to observe the absorption spectrum of the cool atmosphere at different depths.

The most recent and complete study of spectra of Zeta Aurigae taken in partial eclipse is that by O. C. Wilson of the Mount Wilson Observatory. He constructed curves of growth from chromospheric lines of FeI for several different atmospheric heights and found the excitation temperature to increase from about 3800° K. at height 0.8×10^6 km. to 5600° K. at height 13.5×10^6 km. He investigated also the density gradients in the atmosphere for various atoms and ions, finding that they were steepest at lowest levels, becoming less with increasing height. In accordance with earlier investigations, he found the density gradients to be from about twenty times less for hydrogen to 1000 times less for iron than would be expected under mechanical equilibrium. While one can make the general suggestion that the effect arises from radiation

pressure, no satisfactory detailed hypothesis or mechanism has yet been found.

Two summers ago, H. L. Welsh while at Victoria made a study of the behaviour of the chromospheric absorption of the H and K lines of CaII before and after various eclipses. He confirmed that at different eclipses and, indeed, at ingress and egress of the same eclipse, the height of ionized calcium in the atmosphere of the K-star has varied greatly. There seem to be two extents, one normal and the other, encountered so far less often, about three or four times the normal one. Again, while several possible types of explanation have been advanced, they must be considered as tentative, and so the reason for the observed phenomenon is still obscure.

Space is not available to tell the whole detailed story of Zeta Aurigae, but perhaps enough has been said to indicate the interest attached to the star. So far, while we have learned much from it, Zeta Aurigae has posed almost as many new problems as it has solved. However, we look forward to even better observations in the future, yielding new and interesting results. The star 32 Cygni was discovered by D. B. McLaughlin within the last year to be very similar to Zeta Aurigae, and is at present being studied at Victoria by K. O. Wright. Information on the new system should form a valuable check on data from Zeta Aurigae. A third somewhat similar star, VV Cephei, is made up of a giant M-type star and B-type companion. Its period is about 7400 days (20 years) and the next eclipse is in 1957. In this case, total eclipse lasts about 450 days and the partial phases 22 days each. The system is complicated by irregular variation in brightness of the M-type star and varying emission lines in the spectrum. It is nevertheless an object worthy of intensive future investigation.

Isotopes in Stellar Atmospheres.—A step beyond the study of the relative abundances of the elements in stellar atmospheres is the investigation, in the cases where it is possible, of the relative abundances of the isotopes of a given element. This interesting problem is concerned mainly with the late-type stars because all the elements except hydrogen must be investigated by means of molecular spectra.

The Balmer series lines of hydrogen give isotopic shifts of over an angstrom unit between hydrogen and deuterium. Although

several investigations have been made on the subject, no evidence has yet been found in the solar or in stellar spectra indicating a detectable amount of deuterium. The other elements that can be studied are those whose atoms are constituents of molecules responsible for absorption bands of appreciable strength in stellar spectra. Included among the molecules are CH, CN, C_2, TiO, ZrO, NH, OH and MgH. In these molecules the seven elements represented are H, C, N, O, Mg, Ti and Zr.

For four of the seven elements, H, N, O and Ti, there is some evidence that the relative abundances of the isotopes in stellar atmospheres does not depart greatly from their terrestrial values, at least in the direction of the less abundant isotopes having much greater abundances. For two elements, Mg and Zr, to the best of our knowledge no investigations have been made. In the case of carbon, there is fairly definite evidence that the abundance ratio C^{12} to C^{13}, is different for two groups of stars.

It has been apparent since the identification in the spectra of the R- and N-type stars of the isotopic bands of C^{12} C^{13} and C^{13} C^{13} of the Swan system of C_2 that, in almost all the stellar spectra, the intensity of these isotopic bands relative to the main, C^{12} C^{12}, bands was greater than in terrestrial sources of the bands. This observation led to the question as to whether the relative abundance of C^{13} to C^{12} was greater in the stellar atmospheres than in terrestrial carbon where it is about 1 to 90. The general opinion of those who worked on the problem has been a favour of the higher stellar abundance of C^{13}. Within the last few years, at Victoria, a study has been made of the isotopic carbon bands in the spectra of twenty-one R-type stars. The cases encountered are illustrated in plate II. Of the twenty-one stars, three were like the top two star spectra, there being little evidence of C^{13}. For these the C^{12} to C^{13} abundance ratio is about 50 or more. There were twelve stars like the third and fourth spectra where the isotopic C^{12} C^{13} and C^{13} C^{13} bands are apparent. For these twelve stars the abundance ratio C^{12}/C^{13} was found to be remarkably constant and averaged about 3.5. For the remaining six stars, illustrated by the bottom spectrum, the bands were too strong for reliable results to be obtained. There thus appeared to be two groups of stars, one having a C^{12}/C^{13} abundance ratio of 3.5 and the other a ratio $\geqslant$ 50. The carbon in the latter could be like terrestrial samples.

Possible types of explanation of this coexistence of the two groups of stars have been considered. The most attractive hypothesis deals with the effect of the carbon-nitrogen energy-producing cycle on the original C^{12}/C^{13} abundance ratio in primitive matter. The action of the process is to establish the abundance ratio of C^{12} to C^{13} as the inverse of the ratio of the nuclear cross sections for bombardment by protons of thermal energy distribution corresponding to the temperatures of the stellar interiors. However, even the assumption that the carbon-nitrogen cycle operates in the interiors of the cool giant stars has not been established. Nor has it yet been determined whether the relative capture cross section of C^{13} to C^{12} is closer to 90 to 1 or 3.5 to 1 (recent data favour the latter). Correspondingly it cannot be decided whether the ratio of C^{12} to C^{13} in the primitive material should be taken as 3.5 or as 90. The whole problem is an interesting one, linking as it does nuclear physics and astrophysics, and having possibly important bearing on our knowledge of stellar evolution. Work on the carbon isotopes in stellar spectra is being continued at Victoria and elsewhere, and it is hoped that further significant results may be obtained.

Emission Lines in the Spectra of the Long-Period Variable Stars.—The long-period variable stars include a large fraction of the giants of spectral types M, N, and S. They vary in total luminosity (mostly in the infra-red spectral region) by about one magnitude, with periods of several hundred (100-500) days. While the total luminosity varies by only one magnitude, the variation in the ordinarily observed visual and photographic regions is about 5 magnitudes, or a factor of 100. The temperature drops somewhat with decreasing luminosity and the spectral types change correspondingly by several tenths of a spectral division. The features to be discussed are the emission lines which occur in the spectra of most of the long-period variables. These lines vary in intensity cyclically. At minimum light there are few if any emission lines present in the spectrum. As the star brightens, about half way to maximum hydrogen emission lines of the Balmer series appear, and they increase in intensity until just past maximum light, when they begin to fade, disappearing before minimum. Low excitation lines of SiI, FeI and FeII are often seen by maximum light. The greatest development of the emission spectrum takes place in the

post-maximum period when many lines of FeI, FeII, MgI, MnI, etc., are found. P. W. Merrill has measured about 250 emission lines between λ3200 and λ4900 in the spectrum of Chi Cygni. These lines disappear by minimum light.

The emission lines in these cool giant stars pose two problems. First, how are they excited? What process produces the lines and in what part of the atmosphere do they arise? Secondly, how is the cyclical variation in intensity of the emission lines to be explained? Neither of these questions has yet been answered, although there are various observational clues, some of which I shall mention.

Regarding the place of origin of the emission lines, present evidence indicates it to be well below the outermost regions of the atmosphere. Two related sources of evidence are present. The Balmer emission lines have an irregular decrement in intensity, Hε being very weak or absent at most times. This absence is ascribed to absorption of the line by overlying layers of CaII, the λ3969 H-line of which absorbs Hε. Other irregularities can be traced to suitable atomic or molecular absorbers. Furthermore, when the relatively broad hydrogen emission lines are examined with high dispersion, as has been done extensively at the Mount Wilson Observatory, they are found to have irregular fine structure. The absorption features causing the structure have been identified with stellar absorption lines of FeI, TiI, TiII, etc., with little or no ambiguity. A. H. Joy has so identified over 60 minima in the lines from Hα to H35 in the spectrum of Mira Ceti. The evidence that absorbing matter lies above the region of hydrogen emission is thus quite strong. This conclusion is not what one would expect from studies of early-type objects showing emission, where the emission appears to arise in the outermost, most tenuous regions of the atmosphere.

As to the mode of origin of the emission, the situation is obscure. Several suggestions involving molecular dissociation, fluorescence, etc., have been made for particular lines, and involving the presence of hot early-type companions for a few of the stars. The fluorescence-mechanism does give a highly acceptable explanation of the observed selective excitation of a few lines of FeI, and one or two variables, including Mira Ceti, undoubtedly do have hot companion stars that could play a role in excitation of emission

lines. But a fundamental all-embracing explanation of the source of energy and the mechanism of production of the emission lines in the long-period variable spectra has not yet been given.

The question of the cyclical behaviour of the emission-line intensities is the second problem. There is no doubt that the answer is closely related to the origin of the light variations. Some sort of pulsation has seemed so far to be the best hypothesis to explain the latter, but again no complete and satisfactory picture has been forthcoming. Until we know the source and means of production of the emission lines, it is nearly impossible to formulate a theory of their cyclical variation in intensity

While the three general topics treated were chosen arbitrarily, it is hoped that they serve to illustrate the general nature of some of the fascinating and as yet unsolved problems that face the astrophysicist working on late-type stellar spectra.

Dominion Astrophysical Observatory
Victoria, B.C.
May 1950

NOTES AND QUERIES

Death of Mr. H. W. Barker

Mr. H. W. Barker, Recorder of the National Council, died at Toronto on January 29th. The following resolution was presented by Mr. E. J. A. Kennedy, Secretary of the Society, and passed at the February 6th meeting of the Toronto Centre.

With much sorrow we record the passing of another of our most valued members and officer of the Royal Astronomical Society of Canada. Mr. Herbert Whitehead Barker's death occurred on January 29th, 1951. He was enrolled as a member in the year 1910 and has served almost continuously since that time as an officer and on the Council.

He was President of the Toronto Centre during 1943 and 1944, and up to the time of his death was the Recording Secretary of the National Council. He was a most active and enthusiastic member and it would be almost impossible to appraise properly his valuable contribution to the growth and success of the Society. He lived a very full life.

By nature artistic and inquisitive, he was led into many different fields of service. His fine qualities of mind and long experience demanded respect and resulted in his counsel being eagerly sought by many institutions and by his Church. Up to his passing he was on the Board of Governors of the East General Hospital and the Canadian Council of Churches, also acting as Treasurer of the latter body. Among the archives of the United Church will be found some of his writings of the early life of the Congregational Church in Canada up to the time of its merging with others to form the United Church of Canada. These are looked upon now as historical documents of some importance.

Many other activities could be cited but the immediate purpose of this resolution is to convey to Mrs. Barker our sincere sympathy and to express that we share with her the loss of a kindly gentleman who will be remembered not only for his ability and efficiency but most of all for his influence for good in all he undertook.

At the Annual General Meeting of the Society on January 12, 1951, a Resolution was passed regarding the death of Dr. F. S. Hogg. It will appear in the minutes of that meeting in our next issue.

C.A.C.

OUT OF OLD BOOKS

By Helen Sawyer Hogg

Le Gentil and the Transits of Venus, 1761 and 1769

The eleven-year voyage of the French astronomer Le Gentil to the Indian Ocean to observe the transits of Venus in 1761 and 1769 is probably the longest lasting astronomical expedition in history. In fact, it is quite possible that, except for interplanetary travel, there will never be astronomical expeditions to equal in duration and severity those made for that particular pair of transits.

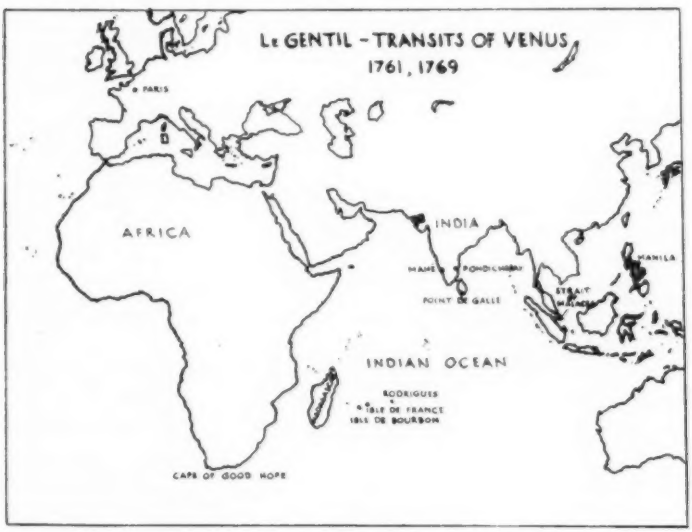
At that time the most important astronomical problem was considered to be the determination of the distance from the earth to the sun by observations of the transit of Venus. The astronomer Halley pointed out this fact in 1716, and urged that astronomers should be sent to distant parts of the world for these transits, which would occur after his death. Observations were needed over a wide range of latitude and longitude. We know now that there are more reliable means of determining the distance of the earth from the sun, so that transits of Venus are unlikely to assume again the importance they held at that time.

The expeditions for this pair of transits, however, constitute one of the most picturesque aspects of historical astronomy. We have already published in this column the experiences of William Wales who made, in 1768, the first astronomical expedition to the Canadian Arctic (this Journal, Nov. 1947, May–August 1948). In the first of these articles we referred to the heart-breaking experience of Le Gentil who, for all his lengthy voyages, failed to achieve any useful observations of either transit. There is little information in the English language about his remarkable journeys. The brief remarks made in the volumes "Transits of Venus", by R. A. Proctor, 1882, and Sir David Gill's Introduction to his wife's volume "Six Months in Ascension", 1878, contain serious misstatements about Le Gentil's trip.

Le Gentil himself published the account of his amazing voyage in two volumes totalling over seven hundred pages, in 1782, entitled "Voyage dans les mers de l'Inde fait par ordre du roi, à l'occasion du passage de Vénus sur le disque du soleil le 6 juin 1761, & le 3 du même mois 1769". By means of a loan of these rare volumes

from Harvard University I have been able to follow Le Gentil's wanderings and studies in the region of the Indian Ocean. Le Gentil's death occurred during the upheaval of the French revolution, and his eulogy was published some years later by J. D. Cassini IV in 1810. I am indebted to the Library of Congress for the loan of this volume entitled "Mémoires pour servir à l'histoire des sciences et à celle de l'observatoire royal de Paris, suivis de la vie de J. D. Cassini, écrite par lui-même, et des Éloges de plusieurs académiciens morts pendant la révolution". A study of these two works, besides giving the background of Le Gentil's expedition, also clears up false impressions created by the above-mentioned English references. He did not, as they state, stay eight years in Pondicherry studying the astronomy of the Brahmins. He was in Pondicherry only two years, and Indian astronomy was only one of his many pursuits there.

By means of excerpts which Miss Sally Hogg and I have translated from these two works, we can follow briefly the life of Le Gentil, and more fully some of the picturesque aspects of his eleven years of wanderings around the Indian Ocean. On the accompanying map, the places which Le Gentil visited are indicated. We translate the account of his early years as given by Cassini.



EULOGY OF M. LE GENTIL

Guillaume-Joseph-Hyacinthe-Jean-Baptiste Le Gentil was born at Coutances, Sept. 12, 1725. His father, a not very well-to-do gentleman of Normandy, nevertheless knew how to make sacrifices to procure a good education for him. . . .

After having made his first studies at Coutances, the young Le Gentil left his province and came to Paris. Not knowing at first to what career he wanted to commit himself, he began by studying theology and took the ecclesiastical garb. . . . M. Le Gentil kept the apparel of abbé only until the title of "savant" procured him a less equivocal esteem and existence.

The abbé Le Gentil, in pursuing his course of theology, had the curiosity to come sometimes to the Royal College to hear the celebrated Professor Delisle. The lessons of astronomy soon detracted from those of theology. The young man found it much more agreeable to spend the evenings in observing the heavens than to spend a part of the day on the benches of the school disputing vain arguments. He continued his new course, and distinguished himself to his illustrious professor, whose goodwill he knew how to merit. One of his friends having proposed to take him to the Observatory and to present him to MM. Cassini, he eagerly seized the opportunity to form a liaison so profitable to his budding taste for the science of the stars.

Jacques Cassini, then 71 years old and dean of the astronomers of the Academy, received him with that grace, that patriarchal good will which touched and won so easily the heart of a young man. The old man regarded as his children all those who wished to devote themselves to astronomy. Informed of the inclination of the young Le Gentil, he proposed to him to come to work at the Observatory under the direction of Cassini de Thury, his son, and of Maraldi his nephew, already members of the Academy of Sciences. . . .

In a few years the new astronomer became familiar with the use of the instruments, the most delicate observations, and the most difficult calculations. His zeal and his acquired knowledge opened to him the doors of the Academy of Sciences; he was received into it in 1753, and soon justified his nomination by a great number of Memoirs on different points of astronomy that he treated with a great deal of sagacity. Some years after, in 1760, there occurred a brilliant occasion to show a great zeal and a beautiful devotion for the sciences; M. Le Gentil did not let it escape him.

The epoch was approaching for this first transit of Venus on the sun, awaited for such a long time, which should finally decide a great question on the parallax and on the distance of the planets. This determination of one of the most important points of the system of the world had occupied for centuries astronomers who were not at all agreed amongst themselves. . . . Everybody appeared therefore to be interested in the preparation for the voyages which were to be carried out by the savants of all nations, to go to different points of the globe to observe the passage of Venus on the disk of the sun, which was to take place June 6, 1761. Everyone was most thankful to the courageous men who were consigning themselves to these distant journeys; and everyone formed for their success wishes as ardent as those which formerly accompanied the departure of the expedition of the Argonauts. . . . M. Le Gentil solicited and obtained the honor of being in the number of voyageurs proposed by the Academy and named

by the Government. The abbé Chappe was destined for Siberia; the abbé Pingré, for the Isle of Rodrigues; Mason, for the Cape of Good Hope, and Le Gentil, for Pondicherry.

In order to get to Pondicherry, a French possession on the south-east coast of India near the tip, Le Gentil had to take the long route around the Cape of Good Hope to the Isle de France, now called Mauritius, where he would hope to contact a vessel bound for India. He had a choice of two vessels of the East India company ready to sail for the Isle de France, and chose the Berryer, of fifty cannon. The Duke de la Vrilliere had given the East India company very definite orders for Le Gentil's passage to India. He embarked on the vessel the 26th of March, 1760, and arrived at the Isle de France the 10th of July. He makes little comment on his voyage to this island, but we are led to infer that his first sea trip was not completely pleasant when he remarks, apropos of a trip some years later, "Sea voyages no longer cost me anything, I had become so familiar with this element."

At the Isle de France he learned that war had flared up in India between the French and the British, and that he would have considerable difficulty getting there. Too, the season was approaching when the north-east monsoon forced the vessels to sail by a long and tedious route. There was no vessel bound for India from the Isle de France. As Le Gentil waited there during the summer and fall he became afflicted with a type of dysentery which led him to fear that even if a ship sailed, he might be unable to go. For some time he toyed with the idea of going to the island of Rodrigues a hundred leagues to the east, where M. Pingré was to observe the transit.

Just as he was making preparation to go to this island, a frigate arrived from France on February 19, 1761, bearing news of the utmost importance for India. This determined the governor and the commander-in-chief of the naval forces to despatch a frigate to India immediately. Everyone assured Le Gentil that even in the contrary season a frigate like the Sylphide would make the passage from the Isle de France to the coast of Coromandel in two months. Le Gentil left the Isle de France on this frigate the 11th of March, and left the Isle de Bourbon, now Reunion, the 23rd of the same month. As long as they were in the control of winds from the south-east they made thirty to forty-five leagues a day, but when

they entered the region of the monsoons, at latitude 7 degrees south, the favourable wind abandoned them and the north-east monsoon blew them directly opposite to the route they wished.

In this way we wandered around for five weeks in the seas of Africa, along the coast of Ajan, in the Arabian seas. We crossed the archipelago of Socotra, at the entrance to the gulf of Arabia. We appeared before Mahé, on the coast of Malabar, the 24th of May; we learned from the ships of this country that this place was in the possession of the English, and that Pondicherry no longer existed for us. Without stopping further, we set sail. I would not yet have despaired if we had followed our first object to go to the coast of Coromandel; but they made, to my great regret, the resolution to return to the Isle de France. Nevertheless we did hesitate about twenty-four hours at Point de Galle, island of Ceylon; the Dutch there confirmed the news that we had learned at Mahé.

The winter at Galle was in full force; we went through a hard time. We left this coast the 30th of May; the great breeze with which we were accompanied took us to the Isle de France the 23rd of June.

I shall not enter here into greater discussion about this expedition, of the route that I had thought that we would take, and that which we did take. . . . This memoir which is only an extract from my journal which I kept quite regularly day by day shows that I busied myself as I ought with my observations, that my aim was always to go to the coast of Coromandel and that I should not be blamed if I did not appear there; it is a justice which I beg astronomers to do me and which I will have reason to expect from them when they see the details of my memoir. On June 6 I was at 5 degrees 45 minutes of south latitude, and almost 87 degrees 15 minutes of longitude east of Paris. I observed as best I could the transit of Venus, its beginning and end. This observation which I neither published nor calculated has remained as it was made with remarks in a sealed memoir of which I spoke above.

One can imagine the feeling of complete frustration that Le Gentil must have had, to have sailed thousands of miles and spent over a year only to be turned back from land when he was but a few hundred miles from his goal. Although he saw this first transit, his observations, made from a moving ship with uncertainty in the position and the time, could be of no value.

Though he failed to get useful observations of the transit, he was determined to bring back scientific knowledge of the places he was visiting. He was particularly interested in accurate mapping and determination of latitude and longitude, and states

It is known that geography owes its actual perfection to the progress which astronomy has made during the last fifty years, and for that reason astronomers must be regarded as the true geographers. . . .

Before going back to Europe I should have liked to go to visit the archipelago which is north of the Isle de France and to determine its position; I wanted to do

the same thing along the east coast of Madagascar, an island which we frequent a lot and of which we know very little. This work which required several years' stay in these seas compensated me to some extent and made me wait for the transit of Venus in 1769, the sole and last transit that the present generation could hope to see. I resolved then not to leave the Indian Ocean until this time, to make all the observations that I could on geography, natural history, physics, astronomy, navigation, winds, and tides. I was unable to visit the archipelago to the north of the Isle de France; but I made several voyages to Madagascar. I began with Fort Dauphin where from the time of M. de Flacourt we had had an establishment whose remains I still saw in 1761. I was singularly struck, to say so in passing, with the beauty of this island and the fertility which it appeared to have in comparison with the Isle de France.

The provisions are excellent at Fort Dauphin: fish are very abundant and very good, poultry the same; the beef offends only because it is too rich; it causes many people a very dangerous sickness of which M. de Flacourt speaks in his history of Madagascar: he tells at the same time of the means to avoid it. It was with this sickness that I was attacked three or four days after my return to the Isle de France because I had not used the methods set forth by M. de Flacourt. This sickness was a sort of violent stroke, of which several very copious blood-lettings made immediately on my arm and my foot, and emetic administered twelve hours afterwards, rid me quite quickly. But there remained for seven or eight days in my optic nerve a singular impression from this sickness; it was to see two objects in the place of one, beside each other; this illusion disappeared little by little as I regained my strength. . . .

For the next few years Le Gentil stayed at the Isle de France, from which he made numerous excursions to Madagascar and the Isle de Bourbon. He made a map of the east coast of Madagascar which he states to be much better for navigation than any existing map; he studied the customs and garb of the people there, as well as much natural history. He carried on many observations of refraction, of the winds and the monsoons.

These different occupations had led me up to the year 1765. It was time then to think of the second transit of Venus. . . .

After having calculated this transit for India, for Manila, for the Mariana Isles, Mexico, and finally for Europe, I saw that evidently the Mariana Isles and Manila were the sole spots east of Paris the most advantageously placed; not that one could observe at Manila or at the Mariana Islands a greater difference in parallax than on the coast of Coromandel, but because the elevation of the sun above the horizon at the moment of the egress of Venus was to be very great, and would give by this means more hope of succeeding than one could hope for on the coast of Coromandel, where the sun was to be quite low at the moment of the egress of Venus. I knew that the coast of Malabar was then plunged into the most frightful winter; I thought that for this reason it was useless to think of Malabar. I therefore did not waver in making up my mind and in searching for

means of going to Manila. The execution of this plan was not difficult by taking the route to China; because the ships of the India company which passed by the Isle de France to go to China would have taken me as far as there; and from Canton to Manila one finds opportunities every year. All that would still have made a little trouble however, from which I was rescued by the most fortunate event; it was the warship the Bon Conseil from his Catholic Majesty, with sixty-four cannon, which was going from Cadiz to Manila and which various circumstances forced to put into port at the Isle de France.

I soon became acquainted with the captain Don Juan de Caseins, through Don Juan de Langara, one of the first officers of the ship. I had seen M. de Langara in Paris. When he knew my plan, he very obligingly offered me passage on his ship. This opportunity appeared so good to me that I did not hesitate to accept it. . . .

I finally left the Isle de France May 1, 1766, quite resolved to say good-bye forever to that island; and indeed I had conceived the plan of going back to Europe by way of Acapulco, and thereby finish my trip around the world; but I had not foreseen what was to happen to me at Manila, and that a last adventure had destined me for the Isle de France. We arrived at Manila August 10th. Our voyage was rather long; it had its difficulties and its wearinesses.

Don Juan de Caseins introduced me to the governor of Manila in the letter in which he informed him of our arrival. August 13th, four days afterwards, I went down with M. de Caseins and I went to see the governor to whom I gave a letter of recommendation which had been given to me by M. Desforges, governor of the Isle de France.

We were anchored at Cavité, the port of Manila, about three leagues from that city. We found in this port a little vessel with three masts ready to sail for the Mariana Islands. Although the voyage which I had just made had quite tired me and I needed a little rest, I forgot when I saw this ship , all the fatigues which I had just undergone, and I wanted only to go aboard in order to pursue my course to the Marianas. . . . M. de Caseins, to whom I had promised before his departure from Manila to determine the longitude of the city, was the reason that I took no serious steps to embark. He had assured me that I should not lack opportunities to go to these islands by embarking on one of these galleys, and that he would recommend me for that to the governor. Therefore I abandoned for the moment the project of the Marianas. It was a great piece of good fortune for me; for the ship and everything in it perished when it was going out of the Strait of the Philippines to enter the south seas. It is true that only three or four people were drowned, those who were the most eager to save themselves, which is what almost always happens in shipwrecks. I cannot answer that I would not have increased the number of persons eager to save themselves; but I would have lost all my journals and my astronomical instruments, an irreparable loss for me.

After we had acquitted ourselves of a vow which Don Juan de Caseins had made when approaching the Philippines, in bad weather, with which we were troubled for seven days, my first care was to determine the longitude and latitude of Manila. . . .

I became acquainted with Don Estevan Roxas y Melo, and with Don Andres Roxo. The elder Melo was a native of Lima, and canon of the cathedral church of Manila; he was a very inquisitive man, learned, having studied, keen on books and mathematical instruments. The Peruvians have excellent qualities of heart and are very good friends. Don Estevan Melo did me the greatest services during my stay in Manila. Don Andres Roxo was Mexican; he had come to Manila with his uncle Don Manuel Antonio Roxo, Archbishop of Manila; he was his secretary. . . . I divided my time between the house of Don Andres Roxo and the house of Don Estevan Roxas y Melo. Our intimacy has lasted even until now. I have received regularly every year since my departure from Manila news of these two friends; the last told me that death had carried off one of the two, Don Estevan Roxas y Melo.

Manila is without contradiction one of the most beautiful countries in the seas of Asia; the climate is excellent there, the soil is of the greatest fertility. The Philippines have fifteen or sixteen fine ports, and they are covered with the finest woods for building. At Cavité I saw some of these woods which were of a huge size, and a table in the sacristy of the Jesuits in Manila which was eleven feet in diameter and proportionately thick; it was made of a single piece drawn from the trunk of one of these trees. This table is at present in Spain; M. de Caseins took it to the king. . . .

The wood called *tindalo* is one of these fine kinds of wood; it is of a dark red, ferruginous, solid, and very heavy; it is capable of being very finely polished which makes it shine like a mirror; this wood does not warp nor spoil. Don Estevan y Melo had made from this wood expres ly for me a table with a rim and folding stool with which he presented me two weeks before my departure from Manila. This table was twenty-two inches broad and twenty-eight long and made of a single board, and it gave me so much pleasure through the beauty of its wood that I regretted using it on ship. I wrapped it up as best I could, and I brought it with me to Paris where it arrived in a very good state, and where I keep it as a curious piece of furniture and as a monument which always recalls to me with pleasure the memory of so true a friend as Don Estevan Roxas y Melo.

(*To be continued*)

REVIEW OF PUBLICATIONS

Latin Treatises on Comets between 1238 and 1368 A.D. by Lynn Thorndyke. 275 pages, 6 × 9 inches. Chicago: University of Chicago Press, 1950. Price $5.00.

In this volume are printed the texts of important tracts on comets published between 1238 and 1368, and never brought together before. There are thirteen in all, although one of them refers to a solar eclipse of March 1332, three months before the appearance of a comet seen by the observer of the eclipse. Two of them are translations into English. In all the other cases there is an introduction and then the Latin text.

Comets have had an important part in astronomical history and this volume is a valuable contribution to that part dealing with the Middle Ages. To those interested in tracing the development of scientific theory as it emerged from superstition the publication has special value.

The author is professor of history at Columbia University and a former president of the History of Science Society.

C. A. C.

Der Sternenhimmel, 1951; pages 110, 5¾ × 8¼ inches. Published by H. R. Sauerländer & Co., Aarau, Switzerland. Price $2.05 (American), through Mr. Albert J. Phiebig, 545 Fifth Ave., New York 17, N.Y.

This is the eleventh of a series of handbooks published annually under the auspices of the Swiss Astronomical Society in a form similar to that of our own "Observer's Handbook". It is edited by Robert A. Naef of the journal "Orion", and contains much interesting and useful material for amateur and professional alike.

A description of the sky and astronomical phenomena month by month is given, with an accompanying and more detailed daily calendar. Ephemerides of the sun, moon, and planets are given, and a useful table of the brighter asteroids, (in opposition), is included. Positions of interesting clusters, nebulae, bright variable and double stars are listed, meteor showers noted, important lunar occultations shown by diagram, and mention made of other interesting phenomena.

This fine handbook once again demonstrates the active character of the Swiss and their astronomical organization. "Orion" is another of their publications. It is remarkable that so much of astronomical worth is forthcoming from such a small country.

WILLIAM HOSSACK.

The New Zealand Astronomical Handbook, 1951. Pages 28 + iv, $6\frac{1}{4} \times 9\frac{1}{2}$ inches. Published by the Royal Astronomical Society of New Zealand, Carter Observatory, Wellington, N.Z. Price, 3/6.

This is the seventh edition of an annual observer's handbook. Almost a third of the book is photographs of sections of the moon, with identification and description of the various lunar features. Other phenomena of interest to the observer are included, and some details of computation are given for the more mathematical enthusiasts. The New Zealanders are to be congratulated on their distinctive little handbook.

WILLIAM HOSSACK.

MEETINGS OF THE SOCIETY

AT TORONTO

November 14, 1950.—The meeting was held in McLennan Physics Laboratory, the Chairman being Mr. A R. Clute, President. This meeting was recorded by Mr. B. Gunn.

Five candidates were elected to membership in the Society:

Mr. Robert J. Atchison, 110 Ranleigh Ave., Toronto 12.
Mr. Charles A. Godden, 44 Westview Blvd., Toronto.
Dr. F. Russell Kirkham, M.D., 12 Lawton Blvd., Toronto 12.
Mr. Douglas N. McPhie, 56 Castle Frank Rd., Toronto 5.
Miss Eileen Rodd, 119 Springhurst Ave., Toronto 3.

Upon motion of the Secretary, and with the approval of the members present, the Nominating Committee, for nomination of officers for 1951, was elected, consisting of Dr. J. F. Heard, Mr. H. W. Barker and Miss Ruth J. Northcott.

Mr. Raymond Pearce was nominated to the National Council. The President suggested that Mr. Pearce preside for the remainder of the meeting. This suggestion was carried out.

Miss Barbara Creeper was the first of three to speak on "Winter Constellations." She described Cassiopeia, Cygnus, Lyra and Draco, stressing historical connections. Mr. Kurt Frenkel talked about Orion, Auriga, Canis Major, Canis Minor and Leo, working in a discussion of variable stars, meteor showers and dwarf stars. Mr. Raymond Pearce stressed the mythological picture of the constellations. He described Cetus, Andromeda and Gemini; and showed the relative positions of the winter constellations in general.

The speakers answered the questions of various members.

The election of Mr. F. W. Tracy to the Society was declared to be null and void, the motion being made by Mr. A. Bell, seconded by Mr. Sherrick.

AT LONDON

May 19, 1950.—The meeting was held at the Cronyn Memorial Observatory at 8.30 p.m. In the absence of the President, Rev. W. G. Colgrove occupied the chair.

The presence of Mrs. Alice Davies, the former secretary-treasurer, who had just recovered from an extended illness, was noted with pleasure.

Mr. E. E. O'Conner presented a paper on "The Planet Mars," which was illustrated with lantern slides. Mr. O'Conner prefaced his remarks by a description of a motor trip to Flagstaff, Arizona, the chief object of interest there being the Lowell Observatory. It has a 24-inch refractor and was established in 1893 by Percival Lowell for the study of the markings on Mars. The observatory possesses also a 42-inch reflector which figured prominently in the discovery of the planet Pluto.

Of the many interesting things mentioned about Mars was the matter of its satellites. Swift in his "Gulliver's Travels" had referred to the planet having two satellites, with periods of 10 hours and 21½ hours. In 1877 two satellites were discovered by Hall with the 26-inch refractor at the Naval Observatory at Washington, D.C., and they had periods 7h. 39m. and 30h. 18m., remarkably close to Swift's speculation.

Dr. George F. Walden then spoke on "Saturn", with its magnificent system of rings. In this it is unique in the solar system. Since Galileo first saw the rings of Saturn with his new telescopes, they have been a source of study by great astronomers. Saturn has nine known satellites, discovered as follows: Huygens, 1, 1655; Cassini, 4, 1671-84; W. Herschel, 2, 1789; Bond, 1, 1848; W. H. Pickering, 1, 1899. The changes in the appearance of the rings in the period of the planet's revolution were described and were illustrated by a model. Other interesting details were given by Dr. Walden.

The last item on the programme was a talk on the constellations by Rev. W. G. Colgrove, which was very interesting to the members.

October 27, 1950.—Tenth Anniversary of the Cronyn Memorial Observatory. The dedication of the Observatory took place on October 25, 1940. It was presented to the University of Western Ontario by Mrs. Frances Amelia Cronyn as a memorial to her husband Hume Cronyn who was an M.P. and a Member of the Union Government during the First Great War.

First there was an informal dinner at the Fingal dining hall at which forty-three members and their guests sat down.

After this, a private demonstration of the Spitz planetarium was given by Prof. A. E. Johns of McMaster University in a room in Thames Hall. This instrument, costing about $2000, was donated to McMaster University, Hamilton, by the Centre of the R.A.S.C. in that city. This instrument is not so elaborate as the Zeiss planetarium but it proved very effective.

Then followed a lecture by Dr. H. R. Kingston, to whose long-continued and earnest efforts the existence of the Hume Cronyn Observatory is due. He gave a detailed history of the negotiations regarding the observatory and the ultimate triumph in its founding.

By this time a considerable student body had arrived and to the audience Dr. G. R. Magee, the successor to Dr. Kingston as head of the department of Mathematics and Astronomy, introduced Professor Johns who gave a lecture on "Eclipses, Transits and other Astronomical Phenomena." To illustrate it two large blackboards having four sides of diagrams and explanations, had been brought from Hamilton.

The final part of the programme was a demonstration to this audience of the Spitz planetarium by Prof. W. J. McCallion who had come with Dr. Johns from McMaster University.

R. E. WINTERS, *Secretary-Treasurer.*

The Royal Astronomical Society of Canada

OFFICERS FOR 1950

NATIONAL OFFICERS AND COUNCIL

Honorary President—The Honourable DANA A. PORTER, Minister of Education for the Province of Ontario.
President—ANDREW THOMSON, M.A., O.B.E., Toronto.
First Vice-President—C. S. BEALS, PH.D., Ottawa.
Second Vice-President—J. F. HEARD, PH.D., Toronto.
General Secretary—E. J. A. KENNEDY, 3 Willcocks St., Toronto.
General Treasurer—J. H. HORNING, M.A., 3 Willcocks St., Toronto.
Recorder—H. W. BARKER, Toronto. *Librarian*—D. W. BEST, D.D., Toronto.
Members of the Council—CHARLES A. BELL, B.A., Windsor, Ont.; DELISLE GARNEAU, Centre Français de Montréal, P.Q.; F. DEKINDER, Montreal, P.Q.; M. J. S. INNES, M.A., Ottawa, Ont.; E. S. KEEPING, M.A., Edmonton, Alta.; GORDON R. MAGEE, PH.D., London, Ont.; Rev. E. F. MAUNSELL, M.A., Hamilton, Ont.; RUTH J. NORTHCOTT, M.A., Toronto, Ont.; GORDON SHAW, Victoria, B.C.; G. M. SHRUM, PH.D., Vancouver, B.C.; A. V. THOMAS, Winnipeg, Man.; F. L. TROYER, Toronto, Ont.

TORONTO CENTRE

Honorary President—C. A. CHANT, PH.D. *President*—A. R. CLUTE, K.C.
First Vice-President—FRANK S. HOGG, PH.D.
Second Vice-President and *Secretary*—FREDERIC L. TROYER
Treasurer—T. H. MASON *Recorder*—W. R. HOSSACK
Council—D. S. AINSLIE, PH.D.; C. A. CROOK; GEORGE T. DALE; FRED T. GRAHAM; GORDON HEPBURN, B.A.Sc.; MISS A. HISCOCK; A. MILNE; W. R. SHERRICK; NORMAN N. WRONG, M.D.; and the *Past Presidents*—E. J. A. KENNEDY; J. R. COLLINS; S. C. BROWN; REV. D. W. BEST; MISS RUTH J. NORTHCOTT, M.A.; H. W. BARKER; J. F. HEARD, PH.D.

OTTAWA CENTRE

Honorary President—R. MELDRUM STEWART *President*—PETER M. MILLMAN
1st Vice-President—DUNCAN A. MACLULICH *2nd Vice-President*—MORRIS J. S. INNES
Secretary—CAROLINE B. HICKS *Treasurer*—STANLEY A. MOTT
Council—C. S. BEALS; FRANCIS W. MATLEY; MIRIAM S. BURLAND; GEORGE OLTMANN; R. GLENN MADILL; and the *Past Presidents*—MALCOLM THOMSON; HOYES LLOYD; T. L. TANTON.

HAMILTON CENTRE

Honorary President—W. T. GODDARD *President*—W. J. MCCALLION, M.A.
Vice-President—O. J. PATON
Secretary-Treasurer—GEORGE MURCHIE, 77 Fennel Avenue, W., Hamilton
Curator—G. E. CAMPBELL, M.A.
Council—F. SCHNEIDER; F. SISMAN; L. O. JONES; B. WISHART; DR. MARTIN JOHNS; L. W. WELBOURN; and *Past Presidents*—REV. E. F. MAUNSELL, T. M. NORTON; W. S. MALLORY; DR. A. E. JOHNS; W. D. STEWART; H. B. FOX.

WINNIPEG CENTRE

Honorary President—L. T. S. NORRIS-ELYE *President*—E. R. GARDNER
Vice-President—H. E. RASMUSSEN *Treasurer*—MISS M. E. WATTERSON
Secretary—J. A. WHITE, 248 Good Street, Winnipeg
Council—D. R. P. COATS; C. G. CARD; V. C. JONES; MISS OLIVE A. ARMSTRONG; MRS. J. A. NORRIS.

VICTORIA CENTRE

Honorary President—DR. R. M. PETRIE *President*—DR. J. S. STEVENSON
1st Vice-President—MRS. J. R. NOBLE *2nd Vice-President*—MRS. R. S. EVANS
Secretary-Treasurer—MRS. J. H. WILLIAMS, Dominion Astrophysical Observatory
Recorder—R. C. FAIRALL *Director of Telescopes*—R. PETERS
Librarian—E. H. POPE
Council—G. L. DARIMONT; MAJOR E. R. GIBSON; JOHN JERVIS; MISS Y. LANGWORTHY; REV. I. TAYLOR; DR. ANNE B. UNDERHILL

MONTREAL CENTRE

Honorary President—G. H. HALL *Honorary Vice-President*—A. N. SHAW
President—J. DUFFIE *Vice-President*—DR. D. E. DOUGLAS
Secretary—H. F. HALL, 1441 Drummond Street, Montreal
Recording Secretary—MISS I. K. WILLIAMSON *Treasurer*—C. N. S. YARNELL
Director of Observation—DELISLE GARNEAU *Librarian*—C. M. GOOD
Council—T. D. ARCHIBALD; E. E. BRIDGEN; A. M. DONNELLY; F. DEKINDER; F. P. MORGAN; E. R. PATTERSON; T. O. PLANT; W. B. ROSS; PAUL SCOTT; R. VENOR and *Past President*—D. P. GILLMORE, K.C.

LONDON CENTRE

Honorary President—Dr. H. R. Kingston
Past President—Dr. A. J. Watt
President—Albert Emsley
Vice-President—Rev. W. G. Colgrove
Secretary-Treasurer—R. E. Winters, 1142 Richmond Street, London
Council—O. Kilburn; E. E. O'Connor; Mrs. J. C. Higgins; Dr. G. R. Magee; Mrs. Bunard; M. Johnson.

VANCOUVER CENTRE

President—Dr. A. M. Brooker
Vice-President—Miss G. W. Owen
Secretary—Mr. E. M. Price, 3831 Dunbar Street
Treasurer—Mrs. C. A. Rogers
Recording Secretary—Dr. O. Bluh
Council—Mrs. L. Anderson; Mr. N. Barton; Dr. R. J. Clark; Mr. Carl Jorgensen; Mr. Leaver; Lt. Com. C. A. Macdonald; Dr. K. C. Mann; Mr. N. D. B. Phillips; Mr. M. T. Spence; Mr. J. T. Watters.

EDMONTON CENTRE

Honorary President—Dr. J. W. Campbell
President—Prof. L. E. Gads
Vice-President—S. G. Deane
Secretary—Dr. E. H. Gowan, University of Alberta
Treasurer—Miss A. M. P. Smith
Librarian—Prof. E. S. Keeping
Council—H. M. Burt; S. F. Page; Prof. E. Phibbs; Miss Valens; A. Stockwell.
Social Hostesses—Miss I. Fortune; Mrs. R. N. Shaw; Mrs. E. Siemens.

QUEBEC CENTRE

Patron—Mgr. Ferdinand Vandry, P.A., V.G., Recteur de l'université Laval
Président Honoraire—Arthur Amos, I.C.
Président—Georges-Etienne Gagné
1er Vice-Président—Albéric Boivin
2nd Vice-Président—Claude Frémont
Secrétaire-trésorier—Paul H. Nadeau, 275, rue Saint-Cyrille, Québec
Secrétaire Suppleant—Jean-Pierre Bernier
Secrétaire Adjoint—Mlle Liliane Beaulieu
Publiciste—Léon D. Descarreaux
Membres du Conseil—Alfred Dion; René Constantineau; Albert Duberger; L'abbé Rosario Benoit; Jean-Charles Magnan; J.-Lucien Pouliot; Lionel-Pierre Peloquin; David I. McGill; Gerard Lafontaine.

WINDSOR CENTRE

Honorary President—O. C. Mohler, PhD.
President—Charles A. Bell, B.A.
Vice-President—Russell G. Warwick, B.A.
Secretary—Henry Lee, B.S.E.E.
Treasurer—David Geauvreau
Past President—Daniel C. Bawtenheimer
Librarian—Gordon Wilson
Assistant Librarian—Donald Lever
Council—Robt. C. Bradley, B.A., M.A.; J. J. Coughlin, B.A.; Geo. Currie; D. Rudychuk; Cameron Mentrose; Dan Rahn; Rex Hicks; R. C. Surtees; Jack Evzovitch, B.S.E.E.; Mrs. G. E. Wood.

SASKATOON CENTRE

Honorary President—E. L. Harrington, Ph.D.
President—J. R. Martin, B.A., B.Paed.
Vice-President—A. E. Falk
Secretary—G. R. Small, 634 Saskatchewan Cresc., E., Saskatoon
Treasurer—R. E. Jensen
Council—B. W. Currie, Ph.D.; Wm. Petrie, Ph.D.; Mrs. M. Dezeure; J.H.Erwin, B.A., B.Ed.; J. McNaughton; A. E. Miles; R. H. Trickey, B.Sc., B.Ed.

GUELPH CENTRE

Honorary President—Henry H. Westoby
President—Harold Seekins
Past President—Prof. R. C. Moffatt
1st Vice-President—Prof. V. C. Lowell
2nd Vice-President—Frank Braucht
Treasurer—Roy Schnurr
Secretary—Stewart G. Bruce, Jr., 179 Eramosa Road, Guelph
Council—W. T. Patterson; S. B. MacKay; D. Hatch; S. Lewis; Mrs. G. Currier; Mrs. V. C. Lowell; Mrs. P. Mockford.

CENTRE FRANCAIS DE MONTREAL

Président—Jean Asselin
Vice-Président—Hector Collette
Secrétaire-trésorier—Joseph R. Leduc, 1430, rue St-Denis, Montréal 18
Rapporteur—Gerard Beaudry
Directeur des Observations—DeLisle Garneau
Bibliothecaire—Roger Bonin
Membres du Conseil—Rév. Frère Robert, f.e.c.; Arthur Amos; J. Edgar Guimont; Bernard Boucher; J. Amedee Buteau; Jean Naubert; Romeo W. Grignon.

LONDON CENTRE

Honorary President—Dr. H. R. Kingston — *Past President*—Dr. A. J. Watt
President—Albert Emsley — *Vice-President*—Rev. W. G. Colgrove
Secretary-Treasurer—R. E. Winters, 1142 Richmond Street, London
Council—O. Kilburn; R. E. O'Connor; Mrs. J. C. Higgins; Dr. G. R. Magee; Mrs. Bunard; M. Johnson.

VANCOUVER CENTRE

President—Dr. A. M. Brooker — *Vice-President*—Miss G. W. Owen
Secretary—Mr. E. M. Price, 3331 Dunbar Street
Treasurer—Mrs. C. A. Rogers — *Recording Secretary*—Dr. O. Bluh
Council—Mrs. L. Anderson; Mr. N. Barton; Dr. R. J. Clark; Mr. Carl Jorgensen; Mr. Leaver; Lt. Com. C. A. Macdonald; Dr. K. C. Mann; Mr. N. D. B. Phillips; Mr. M. T. Spence; Mr. J. T. Watters.

EDMONTON CENTRE

Honorary President—Dr. J. W. Campbell — *President*—Prof. L. E. Gade
Vice-President—S. G. Deane — *Secretary*—Dr. E. H. Gowan, University of Alberta
Treasurer—Miss A. M. P. Smith — *Librarian*—Prof. E. S. Keeping
Council—H. M. Burt; S. F. Page; Prof. E. Phibbs; Miss Valens; A. Stockwell.
Social Hostesses—Miss I. Fortune; Mrs. R. N. Shaw; Mrs. E. Siemens.

QUEBEC CENTRE

Patron—Mgr. Ferdinand Vandry, P.A., V.G., Recteur de l'université Laval
Président Honoraire—Arthur Amos, I.C. — *Président*—Georges-Etienne Gagné
1er Vice-Président—Albéric Boivin — *2nd Vice-Président*—Claude Frémont
Secrétaire-trésorier—Paul H. Nadeau, 275, rue Saint-Cyrille, Québec
Secrétaire Suppléant—Jean-Pierre Bernier
Secrétaire Adjoint—Mlle Liliane Beaulieu — *Publiciste*—Léon D. Descarreaux
Membres du Conseil—Alfred Dion; René Constantineau; Albert Duberger; L'abbé Rosario Benoit; Jean-Charles Magnan; J.-Lucien Pouliot; Lionel-Pierre Peloquin; David I. McGill; Gerard Lapontaine.

WINDSOR CENTRE

Honorary President—O. C. Mohler, PhD. — *President*—Charles A. Bell, B.A.
Vice-President—Russell G. Warwick, B.A. — *Secretary*—Henry Lee, B.S.E.E.
Treasurer—David Grauvreau — *Past President*—Daniel C. Bawtenheimer
Librarian—Gordon Wilson — *Assistant Librarian*—Donald Lever
Council—Robt. C. Bradley, B.A., M.A.; J. J. Coughlin, B.A.; Geo. Currie; D. Rudychuk; Cameron Mentrose; Dan Raen; Rex Hicks; R. C. Surtees; Jack Evsovitch, B.S.E.E.; Mrs. G. E. Wood.

SASKATOON CENTRE

Honorary President—E. L. Harrington, Ph.D.
President—J. R. Martin, B.A., B.Paed. — *Vice-President*—A. E. Falk
Secretary—G. R. Small, 634 Saskatchewan Cresc., E., Saskatoon
Treasurer—R. E. Jensen
Council—B. W. Currie, Ph.D.; Wm. Petrie, Ph.D.; Mrs. M. Desbrue; J.H.Erwin, B.A., B.Ed.; J. McNaughton; A. E. Miles; R. H. Trickey, B.Sc., B.Ed.

GUELPH CENTRE

Honorary President—Henry H. Westoby — *President*—Harold Seekins
Past President—Prof. R. C. Moffatt — *1st Vice-President*—Prof. V. C. Lowell
2nd Vice-President—Frank Braucht — *Treasurer*—Roy Schnurr
Secretary—Stewart G. Bruce, Jr., 179 Eramosa Road, Guelph
Council—W. T. Patterson; S. B. MacKay; D. Hatch; S. Lewis; Mrs. G. Currier; Mrs. V. C. Lowell; Mrs. P. Mockford.

CENTRE FRANCAIS DE MONTREAL

Président—Jean Asselin — *Vice-Président*—Hector Collette
Secrétaire-trésorier—Joseph R. Leduc, 1430, rue St-Denis, Montréal 18
Rapporteur—Gerard Beaudry — *Directeur des Observations*—DeLisle Garneau
Bibliothécaire—Roger Bonin
Membres du Conseil—Rév. Frère Robert, f.e.c.; Arthur Amos; J. Edgar Guimont; Bernard Boucher; J. Amedee Buteau; Jean Naubert; Romeo W. Grignon.